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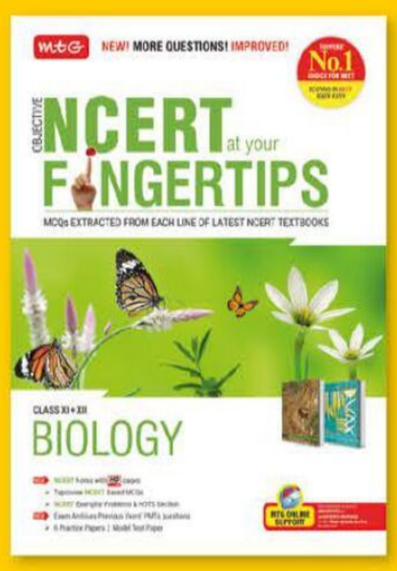

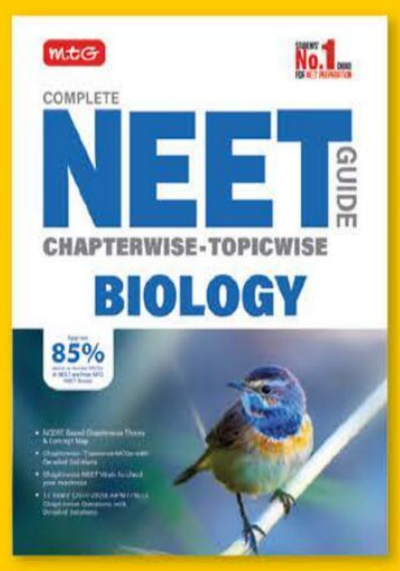

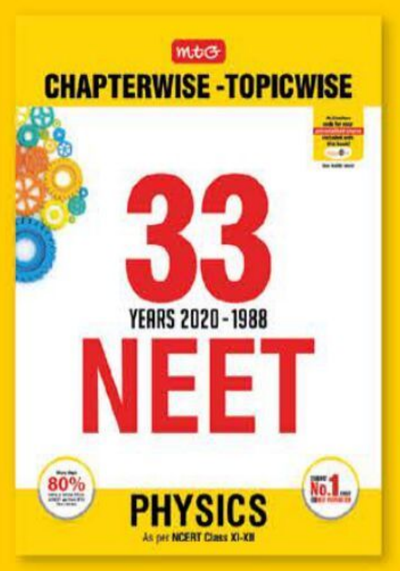

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CHEMISTRY today

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GEAR UP for JEE MAIN 2021

Exam Dates 2021

26th, 27th, 31st August and 1st, 2nd September

Section A will be of Multiple Choice Questions (MCQs). Section B will contain questions whose answers are to be filled in as a Numerical Value. In Section B candidates have to attempt any five questions out of 10.

SECTION A (MULTIPLE CHOICE QUESTIONS)

1. The number of β-particles emitted during the change ${}^{c}_{a}X \longrightarrow {}^{b}_{d}Y$ is

(a) $\frac{a-b}{4}$ (b) $d+\left(\frac{a-b}{2}\right)+c$

(c) $d+\left(\frac{c-b}{2}\right)-a$ (d) $d+\left(\frac{a-b}{2}\right)-c$

2. When the electric current is passed through a cell having an electrolyte, the positive ions move towards cathode and negative ions towards the anode. If the cathode is pulled out of the solution then

(a) the positive and negative ions will move towards anode

(b) the positive ions will start moving towards the anode while negative ions will stop moving

(c) the negative ions will continue to move towards anode while positive ions will stop moving

(d) the positive and negative ions will start moving randomly.

3. Which of the following does not give anti-Markownikoff's product ?

(a) $R_3\overset{+}{N}-CH=CH_2 \xrightarrow{HBr}$

(b) $CH_3-CH=CH_2 \xrightarrow[Peroxide]{HBr}$

(c) $CH_3-CH=CH-CH_3 \xrightarrow[Peroxide]{HBr}$

(d) $CH_3-CH=CH_2 \xrightarrow[Peroxide]{CCl_3Br}$

4. A mixture of two inorganic salts give following chemical reactivity :

(i) Mixture on reaction with dilute H_2SO_4 evolves a colourless and unpleasant gas which turns acidic dichromate paper green.

(ii) Mixture on reaction with concentrated H_2SO_4 gives reddish brown gas which does not produce orange red spots on starch paper.

(iii) The mixture gives white precipitate with barium chloride solution which is soluble in dilute HCl.

(iv) The sodium carbonate extract of mixture responds to brown rings test.

The mixture contains

(a) SO_3^{2-} and NO_3^- anions

(b) S_2^- and NO_3^- anions

(c) S_2^- and NO_2^- anions

(d) SO_3^{2-} and Br^- anions.

5. Select the correct statement.

(a) The order of Xe–F bond length in various fluorides of xenon is $XeF_2 < XeF_4 < XeF_6$.

(b) PH_5 can undergo sp^3d hybridisation to have an octahedral geometry.

(c) Dipole moment of CH_3F is greater than that of CH_3Cl.

(d) Increasing strength of hydrogen bonding is N–H---N < Cl–H---Cl < O–H---O < F–H---F

6. It is an experimental fact that $Cs_2[CuCl_4]$ is an orange coloured but compound $(NH_4)_2[CuCl_4]$ is yellow. The total paramagnetic moment of orange compound is found to be more than that of yellow compound. Then which of the following is correct?

(a) Anion of orange compound is tetrahedral and that of yellow is square planar.

(b) Anion of orange compound is square planar and that of yellow is tetrahedral.

(c) Both the anions are tetrahedral.

(d) Both the anions are square planar.

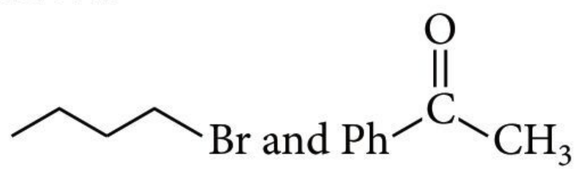
7. Which among the following statements is/are correct?

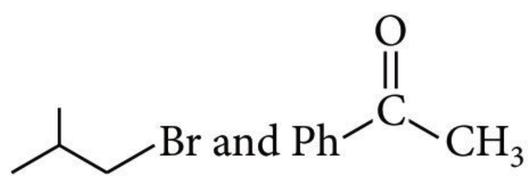
I. Energy needed for homolytic bond fission is less than that required for the heterolytic bond fission.

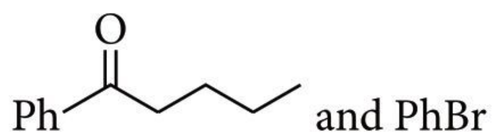
II. Homolytic bond fission gives neutral species which is paramagnetic in character.
III. Energy needed for heterolytic bond fission is less than that required for the homolytic bond fission.
IV. Heterolytic bond fission takes place in non-polar solvents.

(a) Only I (b) Only I and III
(c) Only I and II (d) Only I, II and IV

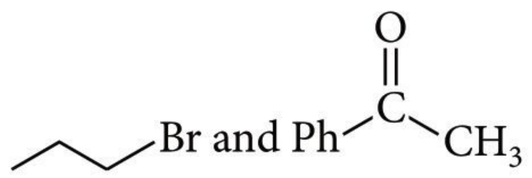
8. 2-phenyl-2-hexanol can be prepared by Grignard synthesis. The pair of compounds giving the desired product is

(a) 

(b) 

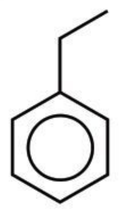
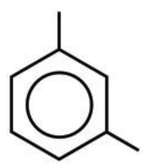
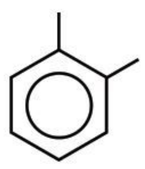
(c) 

and PhBr

(d) 

9. $C_8H_{10}(A) \xrightarrow{KMnO_4} C_8H_6O_4(B) \xrightarrow[Fe]{Br_2} C_8H_5BrO_4\ (C)$

If (*C*) has only one possible structure (one-product only) then deduce structure of (*A*).

(a)  (b)  (c)  (d) 

10. The monomer that can undergo radical, cationic and anionic polymerisation with equal ease is

(a) $Me-\underset{\underset{Me}{|}}{C}=CH_2$ (b) $Ph-CH=CH_2$
(c) $CH_2=CH_2$ (d) $CH_2=CH-CN$

11. Match the column-I with column-II and choose the correct option.

	Column-I (Element/elements)		Column-II (Group number)
(A)	An element whose fourth shell contains two *p*-electrons	(p)	8^{th} group
(B)	An element whose valence shell contains one unpaired *p*-electron	(q)	12^{th} group
(C)	An element which receives last electron in $(n-1)$ *d*-subshell	(r)	14^{th} group
(D)	An element with the ground state electronic configuration $[Ar]4s^2 3d^{10}$	(s)	17^{th} group

	A	B	C	D
(a)	p	q, r	s	q
(b)	r	p, q	q	s
(c)	r	s	p, q	q
(d)	q	p	p, s	r

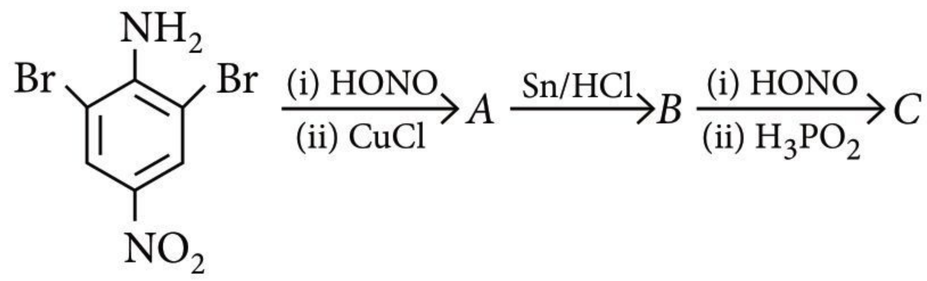
12. When K_2CrO_4 is added to $CuSO_4$ solution, there is formation of $CuCrO_4$ as well as $CuCr_2O_7$. Formation of $CuCr_2O_7$ is due to

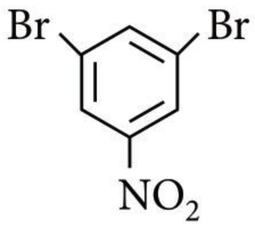
(a) basic nature of $CuSO_4$ solution
(b) acidic nature of $CuSO_4$ solution
(c) $CuSO_4$ oxidizes CrO_4^{2-} to $Cr_2O_7^{2-}$
(d) the typical property of $CuSO_4$.

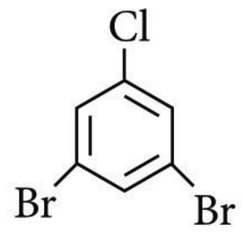
13. The correct order of the increasing *s*-character of the orbital of B which overlaps with the orbital of F to form B – F bond in BF_2^+, BF_3 and BF_4^- is

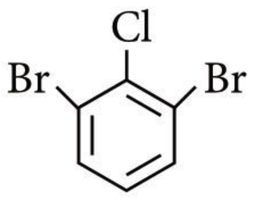
(a) $BF_2^+ < BF_4^- < BF_3$ (b) $BF_3 < BF_2^+ < BF_4^-$
(c) $BF_2^+ < BF_3 < BF_4^-$ (d) $BF_4^- < BF_3 < BF_2^+$

14. The product (*C*) obtained in the following sequence of reactions is



(a) 

(b) 

(c) 

(d) None of these

15. For 'invert sugar', the incorrect statements are (Given: specific rotations of (+)-sucrose, (+)-maltose, *L*-(–)-glucose and *L*-(+)-fructose in aqueous solution are +66°, +140°, –52° and +92°, respectively)

(I) 'invert sugar' is prepared by acid catalyzed hydrolysis of maltose
(II) 'invert sugar' is an equimolar mixture of *D*-(+)-glucose and *D*-(–)-fructose

(III) specific rotation of 'invert sugar' is –20°

(IV) on reaction with Br_2 water, 'invert sugar' forms saccharic acid as one of the product.

(a) II and III (b) I and II

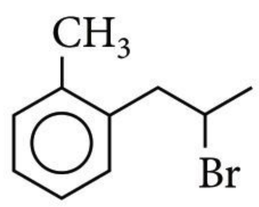
(c) I and IV (d) I, II and IV

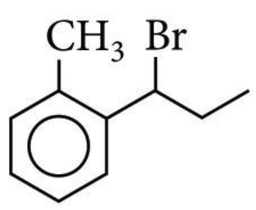
16. $CaCl_2 + H_2SO_4 \xrightarrow[-HCl]{\text{Crystallisation}} CaSO_4.2H_2O \xrightarrow{(p)} (q) \xrightarrow{>393\ K} (r)$

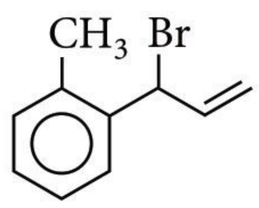
Which of the following option describes *p*, *q*, *r* correctly?

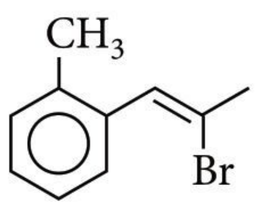
	(*p*)	(*q*)	(*r*)
(a)	Heat at 393 K	$2CaSO_4.H_2O$	$CaSO_4$
(b)	Heat below 393K at high pressure	$2CaSO_4.H_2O$	$CaSO_4$
(c)	Cool	$CaSO_4.H_2O$	$CaSO_4$
(d)	Heat at 393 K	$CaSO_4$	$CaSO_4$

17. Which compound undergoes hydrolysis by the S_N1 mechanism at the fastest rate?

(a) 

(b) 

(c) 

(d) 

18. In cold water, DO (Dissolved Oxygen) can reach a concentration upto *X* ppm whereas oxygen in air is about *Y* ppm. *X* and *Y* are

	X	*Y*
(a)	10	20
(b)	10	2.0×10^5
(c)	10	2.0×10^4
(d)	20	10

19. Consider the following statements :

(A) In the aluminothermite process, aluminium acts as a reducing agent.

(B) The process of extraction of gold involves the formation of $[Au(CN)_2]^-$ and $[Zn(CN)_4]^{2-}$.

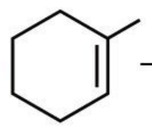
(C) In the extractive metallurgy of zinc, partial fusion of ZnO with coke is called sintering and reduction of ore to the molten metal is called smelting.

(D) Extractive metallurgy of silver from its ore argentite involves complex formation and displacement by more electropositive metal.

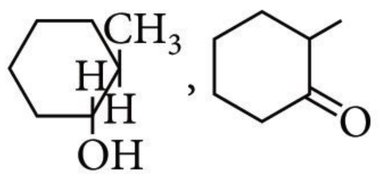
Which of the following statements are true?

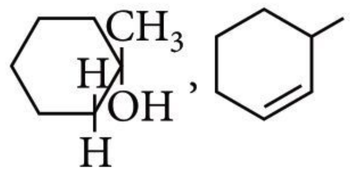
(a) *A* and *B* only (b) *B* and *C* only

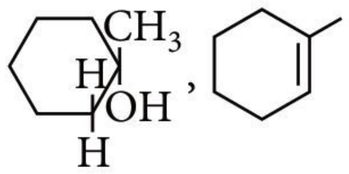
(c) *A*, *B* and *C* only (d) *A*, *B*, *C* and *D*

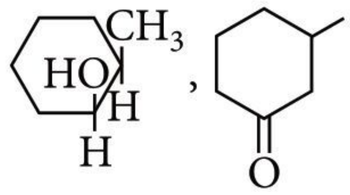
20.  $\xrightarrow[(2)\ H_2O_2,\ OH^-]{(1)\ BH_3,\ THF} A \xrightarrow{Cu,\ 300°C} B$

the products *A* and *B* are

(a) 

(b) 

(c) 

(d) 

SECTION B (NUMERICAL VALUE TYPE)

21. 100 cm^3 of a given sample of H_2O_2 gives 1000 cm^3 of O_2 at STP. The volume strength of sample is

22. Applying Freundlich adsorption isotherm, calculate the amount of acetic acid (in g) adsorbed by 1 kg of blood charcoal at 25°C from a 5% vinegar solution (mass/volume). (Given that if the concentration is expressed in molarity (mol dm^{-3}), x/m is mass of the solute adsorbed per gram of adsorbent, then $k = 0.160$ and $n = 2.32$.)

23. For the reaction, $2NO_2 \longrightarrow N_2O_2 + O_2$, rate expression is as follows $-\frac{d[NO_2]}{dt} = k[NO_2]^n$, where, $k = 3 \times 10^{-3}$ mol^{-1} L s^{-1}. If the rate of formation of oxygen is 1.5×10^{-4} mol L^{-1} s^{-1}, then the molar concentration of NO_2 in mole L^{-1} is

24. A gas mixture contains equal number of molecules of N_2 and SF_6, some of it is passed through a gaseous effusion apparatus. How many molecules of N_2 are present in the gaseous product for every 100 molecules of SF_6?

25. A sample of AgCl was treated with 5.00 mL of 1.5 M Na_2CO_3 solution to give Ag_2CO_3. The remaining solution contained 0.0026 g of Cl^- per litre. The solubility product of AgCl is $x \times 10^{-10}$. The value of *x* is _____. ($K_{sp}Ag_2CO_3 = 8.2 \times 10^{-12}$)

26. When a liquid that is immiscible with water was steam distilled at 95.2°C at a total pressure of 748 torr, the distillate contained 1.25 g of the liquid per gram of water. The vapour pressure of water is 648 torr at 95.2°C, what is the molar mass of liquid?

27. 1 mole of CO_2 gas at 300 K is expanded under reversible adiabatic condition such that its volume becomes 27 times. What is work done (in kJ)? (Given $\gamma = 1.33$ and $C_V = 25.08\ J\ mol^{-1}\ K^{-1}$ for CO_2)

28. The average life of an excited state of hydrogen atom is of the order 10^{-8} s. The number of revolutions made by an electron when it is in state $n = 2$ and before it suffers a transition to state $n = 1$ are $x \times 10^{-10}$ m. The value of x is _____.

29. One mole of N_2H_4 loses 10 mole of electrons to form a new compound Y. Assuming that all nitrogen appear in the new compound, what is the oxidation state of nitrogen in Y? (There is no change in the oxidation state of hydrogen.)

30. A crystal is made up of particles X, Y and Z. X forms *fcc* packing, Y occupies all octahedral voids of X and Z occupies all tetrahedral voids of X, if all the particles along one body diagonal are removed then the formula of the crystal would be $X_a\ Y_b\ Z_c$, the value of $(a + b + c)$ is _____.

SOLUTIONS

1. (c) : $^{c}_{a}X \longrightarrow {}^{b}_{d}Y + m\ {}^{4}_{2}He + n\ {}^{0}_{-1}e$

$\therefore \quad c = b + 4m \quad$ ...(i) and $a = d + 2m - n \quad$ ...(ii)

From (i) and (ii), $n = d + \left(\frac{c-b}{2}\right) - a$

2. (d)

3. (c) : $R_3\overset{+}{N}-CH=CH_2 \xrightarrow{HBr} R_3\overset{+}{N}-CH_2-CH_2Br$

$CH_3-CH=CH_2 \xrightarrow[\text{Peroxide}]{HBr} CH_3-CH_2-CH_2Br$

$CH_3CH=CH-CH_3 \longrightarrow \underset{\text{Symmetrical alkene}}{} CH_3-\underset{\displaystyle Br}{\underset{|}{CH}}-CH_2CH_3$

Markownikoff or anti-Markownikoff is not connected.

$CH_3-CH=CH_2 \xrightarrow[\text{Peroxide}]{CCl_3Br} CH_3-\underset{\displaystyle Br}{\underset{|}{CH}}-CH_2CCl_3$

4. (a) : (i) $SO_3^{2-} + H_2SO_4 \longrightarrow SO_{2(g)} + H_2O + SO_4^{2-}$

$K_2Cr_2O_7 + H_2SO_4 + 3SO_2 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + H_2O$

Green

(ii) $4NO_3^- + 2H_2SO_4 \longrightarrow 4NO_2\uparrow + O_2\uparrow + 2SO_4^{2-} + 2H_2O$

As reddish brown gas does not produce orange red spots on starch paper, it can not be Br_2. So the anion is NO_3^-.

(iii) $SO_3^{2-} + Ba^{2+} \longrightarrow BaSO_3\downarrow$ (white)

$SO_3^{2-} + 2H^+ \longrightarrow SO_2\uparrow + H_2O$

(iv) $2NO_3^- + 3H_2SO_4 + 6Fe^{2+} \longrightarrow 6Fe^{3+} + 2NO\uparrow + 3SO_4^{2-} + 4H_2O$

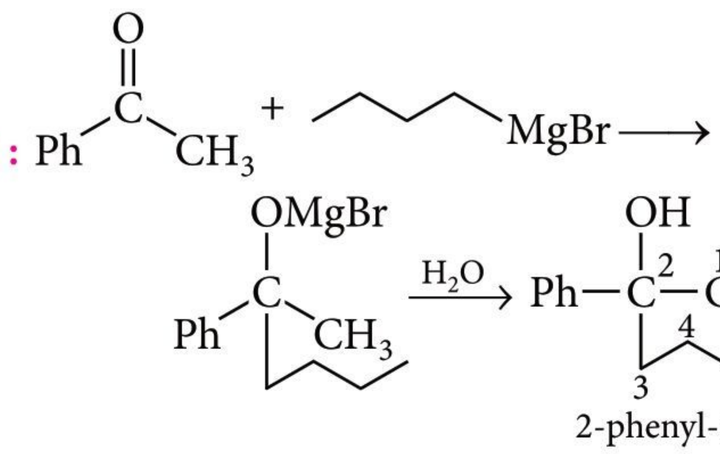
$Fe^{2+} + 5H_2O + NO \longrightarrow [Fe(H_2O)_5NO]^{2+}$

5. (a)

6. (a) : In $[CuCl_4]^{2-}$, orange compound, there is one unpaired electron in *d*-orbital, therefore, its hybridisation is sp^3 whereas in $[CuCl_4]^{2-}$, yellow compound, unpaired electron jumps to 5*s* and thus dsp^2 hybridisation.

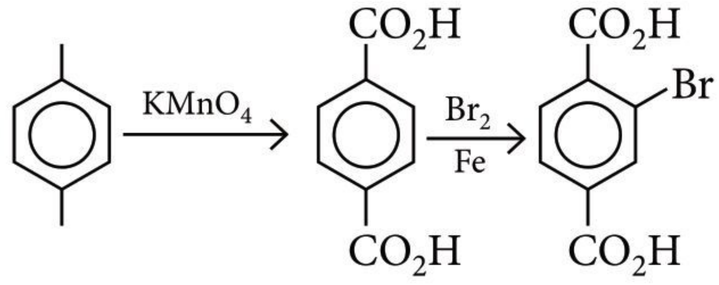
7. (c)

8. (a) :



2-phenyl-2-hexanol

9. (b) :



10. (b) **11. (c)**

12. (b) : Due to acidic nature of $CuSO_4$;

$CrO_4^{2-} \xrightarrow{H^+} Cr_2O_7^{2-}$

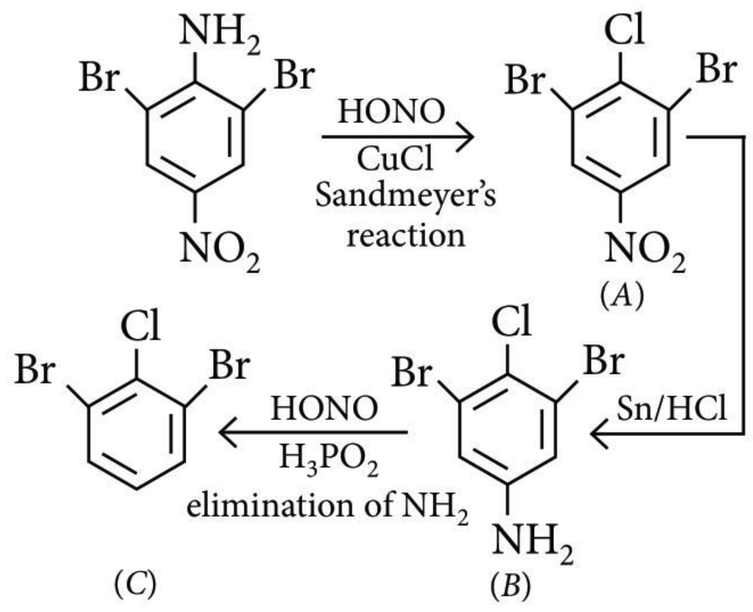
13. (d) :

Hybridisation	sp^3	sp^2	sp
% of *s* character	25	33	50

$\therefore$ The order of increasing *s*-character

$BF_4^-\ (sp^3) < BF_3\ (sp^2) < BF_2^+\ (sp)$

14. (c) :



15. (c) : Invert sugar is prepared by acid catalyzed hydrolysis of sucrose.

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{HCl} \underbrace{\underset{D\text{-(+)-Glucose}}{C_6H_{12}O_6} + \underset{D\text{-(–)-Fructose}}{C_6H_{12}O_6}}_{\text{Invert sugar}}$$

Specific rotation of invert sugar is

$[\alpha]_{mix} = 0.5 \times (+52) + 0.5 \times (-92) = +26 - 46 = -20°$

On reaction with Br_2 water, invert sugar forms gluconic acid as one of the products. Br_2 water oxidises glucose into gluconic acid and fructose is not oxidised by it.

16. (a)

17. (c) : Reaction intermediate carbocation of compound (*C*) is more stable than carbocations of other molecules.

18. (b): DO (Dissolved Oxygen) can reach a concentration upto 10 ppm in cold water while oxygen in air is about 2.0×10^5 ppm.

19. (d): $Cr_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Cr$

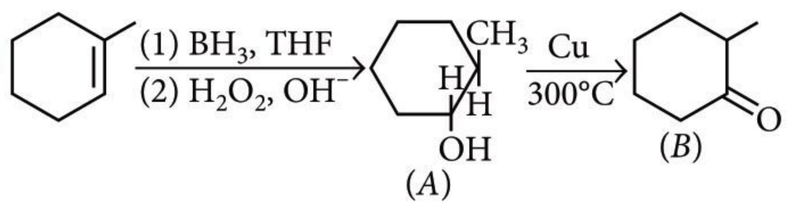
$$Au + 2CN^- + H_2O + \frac{1}{2}O_2 \longrightarrow [Au(CN)_2]^- + 2OH^-$$

$$2[Au(CN)_2]^- + Zn \longrightarrow [Zn(CN)_4]^{2-} + 2Au$$

$$Ag_2S + 4NaCN \xrightarrow{O_2} 2Na[Ag(CN)_2] + Na_2S$$

$$2Na[Ag(CN)_2] + Zn \longrightarrow Na_2[Zn(CN)_4] + 2Ag$$

20. (a) :



21. (10) : $2H_2O_2 \longrightarrow 2H_2O + O_2$

100 mL 1000 mL

or 1 mL of H_2O_2 will give 10 mL of O_2 at STP.

Thus, its volume strength is 10 volume.

22. (147.8) : According to Freundlich adsorption isotherm,

$$\frac{x}{m} = kC^{1/n}$$

5% vinegar (acetic acid solution) means 5 g of acetic acid is present in 100 mL of the solution.

Molar mass of acetic acid (CH_3COOH) = 60 g mol^{-1}

$\therefore$ 5 g of acetic acid = $\frac{5}{60}$ mol

$\therefore$ 1000 mL of the solution will contain acetic acid $= \frac{5}{60} \times \frac{1}{100} \times 1000 = 0.833$ mol L^{-1}

i.e., Concentration of the solution (C) = 0.833 mol L^{-1}

$$\frac{x}{m} = 0.160 \times (0.833)^{1/2.32}$$

$$\therefore \log\frac{x}{m} = \log(0.160) + \frac{1}{2.32}\log(0.833)$$

$$= -0.7959 + 0.431\ (-0.0794) = -0.8301$$

$$\therefore \frac{x}{m} = \text{Antilog}\ (-0.8301) = 0.1478 \text{ g}$$

$\therefore$ Amount adsorbed by 1 kg (1000 g) of charcoal = 147.8 g

23. (0.316) : From the unit of *k*, it is evident that it is a second order reaction.

$$-\frac{1}{2}\frac{d[NO_2]}{dt} = \frac{d[O_2]}{dt}$$

$$\therefore -\frac{d[NO_2]}{dt} = 2 \times \frac{d[O_2]}{dt} = 2 \times 1.5 \times 10^{-4} = 3 \times 10^{-4}$$

$$3 \times 10^{-4} = k[NO_2]^2 = 3 \times 10^{-3}\ [NO_2]^2$$

$\therefore$ $[NO_2] = 0.316$ mol L^{-1}

PUBLIC NOTICE

Rescheduling of Session 4 of JEE Main 2021

In view of the persistent demand from the student community and to enable the candidates to maximize their performance, the National Testing Agency has decided to provide a gap of four weeks between Session 3 and Session 4 of JEE Main 2021. Accordingly, the new dates of the JEE Main 2021 Session 4 are **26, 27, 31 August, and 1, 2 September 2021**. The total number of candidates who have already registered for the JEE Main 2021 Session 4 is 7.32 lacs.

JEE Main 2021	Date of Exams	Downloading of e-Admit Card	Declaration of Result
Session 4 B.E./B.Tech. (Paper-1) & B.Arch. (Paper-2A) / B.Planning (Paper-2B)	26, 27, 31 August, and 1, 2 September 2021	To be intimated later through JEE Main Portal	

The Candidates are advised to keep visiting the official websites of NTA ***www.nta.ac.in*** and ***jeemain.nta.nic.in*** for the latest updates.

24. (228) : $\frac{r_{N_2}}{r_{SF_6}} = \sqrt{\frac{146}{28}} = 2.28$

For 100 molecules of SF_6

$\Rightarrow$ $2.28 \times 100 = 228$ molecules of N_2 required

25. (1.71) : Millimole of $Na_2CO_3 = 5 \times 1.5 = 7.5$

$Na_2CO_3 + 2AgCl = 2NaCl + Ag_2CO_3$

$t = 0$	7.5	0		0
t_{eqm}	$(7.5 - x)$	$2x$		x

Given $[Cl^-] = 0.0026$ g/L $= \frac{0.0026}{35.5}$ mol/L

$= 7.32 \times 10^{-5}$ mol/L

Concentration of Cl^- ion formed $= \frac{2x}{5}$

$\therefore \quad \frac{2x}{5} = 7.32 \times 10^{-5}$

or $x = 1.83 \times 10^{-4}$ millimole

$\therefore$ Millimole of Na_2CO_3 left in 5 mL $= 7.5 - x$

$= 7.5 - 1.83 \times 10^{-4} = 7.5$

$\therefore \quad [CO_3^{2-}] = \frac{7.5}{5} = 1.5$

Now For Ag_2CO_3, $K_{sp} = [Ag^+]^2[CO_3^{2-}]$

$\therefore \quad [Ag^+]^2 = \frac{8.2 \times 10^{-12}}{1.5} = 5.46 \times 10^{-12}$

$\therefore \quad [Ag^+] = 2.34 \times 10^{-6}$

Now For AgCl, $K_{sp} = [Ag^+][Cl^-]$

$= 2.34 \times 10^{-6} \times 7.32 \times 10^{-5} = 1.71 \times 10^{-10}$

26. (145.8) : For two immiscible liquids,

$p_A^\circ = P_{total} - p_{H_2O}^\circ = 748 - 648 \Rightarrow 100$

$\frac{W_A}{W_B} = \frac{p_A^\circ M_A}{p_B^\circ M_B}$; $M_A = \frac{1.25}{1} \times \frac{648 \times 18}{100} \Rightarrow 145.8$ g/mol

27. (–5.016) : $T_1 V_1^{\gamma - 1} = T_2 V_2^{\gamma - 1}$

$300 \times V^{1/3} = T_2 \times (27\ V)^{1/3} \Rightarrow T_2 = 100$ K

$\Delta U = q + W$

For reversible adiabatic process, $q = 0$

Thus, $\Delta U = W \Rightarrow W = nC_V\Delta T$

$W = 1 \times 25.08 \times (100 - 300) = -5.016$ kJ

28. (8.23) : Velocity of electron, in n^{th} orbit

$v_n = 2.19 \times 10^6 \times \frac{Z}{n}$ m s^{-1}

The velocity of electron in second Bohr's orbit,

$v_2 = \frac{2.19 \times 10^6 \times 1}{2}$ m s^{-1}

The circumference of second orbit $= 2\pi r_2$

$= 2\pi \times 0.529 \times 10^{-10} \times 2^2 = 13.3 \times 10^{-10}$ m

$\therefore$ Number of revolutions in 1 sec $= \frac{v_2}{2\pi r_2}$

$= \frac{2.19 \times 10^6}{2 \times 13.3 \times 10^{-10}} = 8.23 \times 10^{14}$

Therefore, number of revolutions made in 10^{-8} sec

$= 8.23 \times 10^{14} \times 10^{-8} = 8.23 \times 10^6$

29. (3) : $N_2H_4 \longrightarrow Y + 10e^-$

Oxidation state of N in $N_2H_4 = 2x + 4 = 0$

$\Rightarrow \quad x = -2$

As 1 mole of N_2H_4 loses 10 moles of electrons, so 1 mole of N loses 5 moles of electrons.

Hence, oxidation state of nitrogen $= -2 + 5 = 3$

30. (17) : When all the particles along one body diagonal are removed, that means two X particles from the corner are removed, one Y particle is removed and two Z particles are removed.

Hence, the new arrangement,

X particle $= \frac{1}{8} \times 6 + \frac{1}{2} \times 6 = \frac{15}{4}$; Y particles $= 3$;

Z particles $= 6$

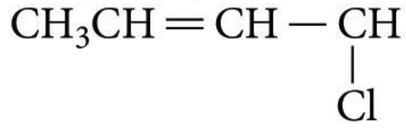
Hence, formula $= X_{15/4}Y_3Z_6 = X_{5/4}YZ_2 = X_5Y_4Z_8$

PRACTICE PAPER

NEET 2021

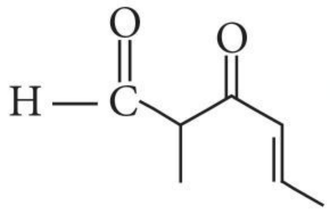
SECTION - A

1. How many stereoisomers are possible for



(a) 5 (b) 4 (c) 6 (d) 8

2. The IUPAC name of the compound

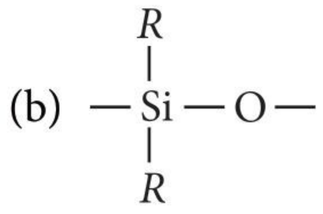


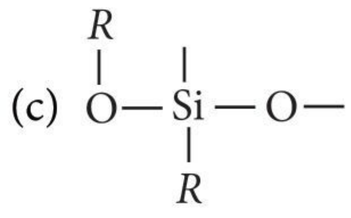
is

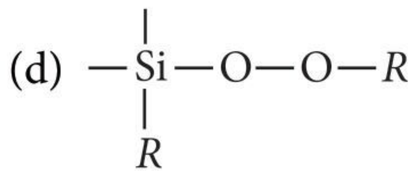
(a) 5-formylhex-2-en-3-one
(b) 5-methyl-4-oxohex-2-en-5-al
(c) 3-keto-2-methylhex-5-enal
(d) 3-keto-2-methylhex-4-enal.

3. The repeating unit in silicone is

(a) SiO_2

(b) 

(c) 

(d) 

4. Which of the following has largest protecting power?
(a) Gelatin (Gold no. = 0.01)
(b) Dextrin (Gold no. = 15)
(c) Potato starch (Gold no. = 25)
(d) Albumin (Gold no. = 0.25)

5. Which of the following does not represent the mathematical expression for the Heisenberg uncertainty principle?

(a) $\Delta x.\Delta p \geq \frac{h}{4\pi}$ (b) $\Delta x.\Delta v \geq \frac{h}{4\pi m}$

(c) $\Delta E.\Delta t \geq \frac{h}{4\pi}$ (d) $\Delta E.\Delta x \geq \frac{h}{4\pi}$

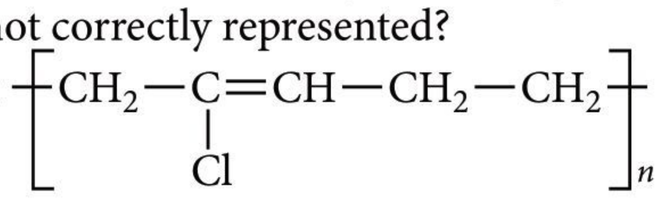
6. When N_2^+ is formed from N_2, bond order _____ and when O_2^+ is formed from O_2, bond order _____.
(a) increases, increases
(b) decreases, decreases
(c) increases, decreases
(d) decreases, increases.

7. Iodine crystal is an example of
(a) metallic solid (b) ionic solid
(c) molecular solid (d) covalent solid.

8. If a compound, on analysis was found to contain C = 18.5%, H = 1.55%, Cl = 55.04% and O = 24.81%, then its empirical formula is
(a) C_2H_2OCl (b) CH_2ClO_2
(c) CHClO (d) $ClCH_2O$

9. Which of the following statements is not true about glucose?
(a) It is an aldohexose.
(b) On heating with HI it forms *n*-hexane.
(c) It is present in furanose form.
(d) It does not give 2,4-DNP test.

10. Structures of some common polymers are given. Which one is not correctly represented?

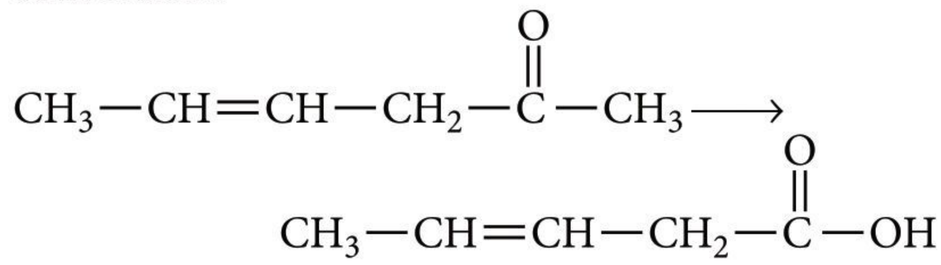
(a) Neoprene : 

(b) Terylene : 

(c) Nylon 6, 6 : $-(\ NH(CH_2)_6NHCO(CH_2)_4—CO\ )_n-$

(d) Teflon : $-(\ F_2C-CF_2\ )_n-$

11. Which is the most suitable reagent for the following conversion?



(a) Tollens' reagent
(b) Benzoyl peroxide
(c) I_2 and NaOH solution
(d) $LiAlH_4/C_2H_5OH$

12. Which of the following is aromatic?
(a) [10]-Annulene (b) [14]-Annulene
(c) [16]-Annulene (d) [18] -Annulene

13. The value of Λ^∞ for NH_4Cl, NaOH and NaCl are 129.8, 248.1 and 126.4 $ohm^{-1}cm^2mol^{-1}$ respectively. The value of Λ^∞ for NH_4OH solution is
(a) 305.6 $ohm^{-1}cm^2mol^{-1}$
(b) 251.5 $ohm^{-1}cm^2mol^{-1}$
(c) 286 $ohm^{-1}cm^2mol^{-1}$
(s) 200 $ohm^{-1}cm^2mol^{-1}$.

14. The basic character of the transition metal monoxides follows the order
(a) CrO > VO > FeO > TiO
(b) TiO > FeO > VO > CrO
(c) TiO > VO > CrO > FeO
(d) VO > CrO > TiO > FeO

15. If $\Delta G = \Delta H - T\Delta S$ and $\Delta G = \Delta H + T\left[\frac{d(\Delta G)}{dT}\right]_P$ then variation of EMF of a cell, with temperature T, is given by
(a) $\frac{\Delta S}{nF}$ (b) $-\frac{\Delta S}{nF}$ (c) $\frac{\Delta H}{nF}$ (d) $\frac{\Delta G}{nF}$

16. Among the following which is least acidic?
(a) Phenol (b) *o*-Cresol
(c) *p*-Nitrophenol (d) *p*-Chlorophenol

17. Which of the following reactions is not of the first order?
(a) Inversion of sucrose in the presence of acid
(b) Acid-catalyzed hydrolysis of ethyl acetate
(c) Hydrolysis of tertiary butyl halide using alkali
(d) Oxidation of I^-ion by $S_2O_8^{2-}$ion.

18. Two gases *A* and *B* having the same volume, diffuse through a porous partition in 20 and 10 seconds respectively. The molecular mass of *A* is 49 u. Molecular mass of *B* will be
(a) 50.00 u (b) 12.25 u
(c) 6.50 u (d) 25.00 u.

19. Which of the following statements is not correct for a nucleophile?
(a) Ammonia is a nucleophile.
(b) Nucleophiles attack low electron density sites.
(c) Nucleophiles are not electron seeking.
(d) Nucleophile is a Lewis acid.

20. Which of the following statements are correct for SO_2 gas?
(a) It acts as bleaching agent in moist conditions.
(b) It has linear geometry.
(c) It's dilute solution is used as lubricant.
(d) It can be prepared by the reaction of dilute H_2SO_4 with metal sulphide.

21. The value of the 'spin only' magnetic moment for one of the following configurations is 2.84 B.M. The correct one is
(a) d^4 (in strong field ligand)
(b) d^4 (in weak field ligand)
(c) d^3 (in weak as well as in strong field ligand)
(d) d^5 (in strong field ligand).

22. Fraction of total volume occupied by atoms in a simple cube is
(a) $\frac{\pi}{2}$ (b) $\frac{\sqrt{3}\pi}{8}$ (c) $\frac{\sqrt{2}\pi}{6}$ (d) $\frac{\pi}{6}$

23. In spite of being an odd-electron molecule, ClO_2 does not dimerise because
(a) the odd electron is delocalised
(b) the odd electron is localised on the chlorine atom
(c) the two Cl – O bonds do not have the same length
(d) of $p_x - p_x$ bonding in the chlorine atom.

24. Which of the following is the correct order of decreasing basic nature of oxides?
(a) Na_2O, MgO, Al_2O_3, CuO
(b) CuO, Al_2O_3, MgO, Na_2O
(c) Al_2O_3, CuO, MgO, Na_2O
(d) CuO, MgO, Na_2O, Al_2O

25. The acid used for the determination of molecular weights of amines is
(a) H_2PtCl_6 (b) picric acid
(c) $HAuCl_4$ (d) H_2SO_4

26. Among the following halides :
1. BCl_3 2. $AlCl_3$ 3. $GaCl_3$ 4. $InCl_3$
the order of decreasing Lewis acid character is
(a) 1, 2, 3, 4 (b) 4, 3, 2, 1
(c) 3, 4, 2, 1 (d) 2, 3, 4, 1.

27. For the reaction : $2A + B \rightarrow C + D$, measurement of the rate of the reaction at varying concentrations are given below :

Expt.No.	[*A*]	[*B*]	Rate (mmol L^{-1} s^{-1})
1.	0.010	0.010	2.5
2.	0.010	0.020	5.0
3.	0.030	0.020	45.0

The rate law is, therefore

(a) rate = $k[A]^2[B]$ (b) rate = $k[A][B]^2$

(c) rate = $k[A][B]$ (d) rate = $k[A]^2[B]^2$

28. Which of the following is not a redox reaction?

(a) $CaCO_3 \longrightarrow CaO + CO_2$

(b) $Na + H_2O \longrightarrow NaOH + \frac{1}{2}H_2$

(c) $MnCl_3 \longrightarrow MnCl_2 + \frac{1}{2}Cl_2$

(d) $O_2 + 2H_2 \longrightarrow 2H_2O$

29. Which of the following cannot be made by using Williamson's synthesis?

(a) Di-*tert*-butyl ether

(b) Methoxybenzene

(c) Benzyl *p*-nitrophenyl ether

(d) Methyl *tert*-butyl ether

30. If latent heat of fusion of ice is 80 cals per g at 0°C, then molal depression constant for water is

(a) 1.05 (b) 1.12 (c) 1.86 (d) 2.12

31. The pair of amphoteric hydroxides is

(a) $Al(OH)_3$, LiOH (b) $Be(OH)_2$, $Mg(OH)_2$

(c) $B(OH)_3$, $Be(OH)_2$ (d) $Be(OH)_2$, $Zn(OH)_2$.

32. Which of the following is an incorrect statement?

(a) Non-ionic detergents are neutral.

(b) The hydrophilic portion of a non-ionic detergent functions by a hydrogen bonding mechanism.

(c) Cationic detergents have a positively charged water soluble portion.

(d) LABS detergents are non-biodegradable.

33. For the electrochemical cell,

$Pt(s)\,|H_2(g)\,|\,H^+(1M)|\,Cu(s)$

(1 atm)

which one of the following statements is true?

(a) H^+ ions are formed at anode and Cu is deposited at cathode.

(b) H_2 liberated at cathode and Cu is deposited at anode.

(c) Oxidation occurs at cathode.

(d) Reduction occurs at anode.

34. Which of the following reactions is appropriate for converting acetamide to methanamine?

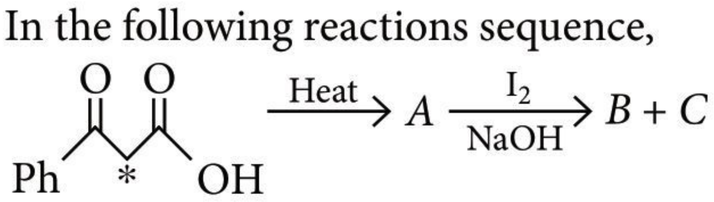
(a) Hoffmann hypobromamide reaction

(b) Stephen's reaction

(c) Gabriel phthalimide synthesis

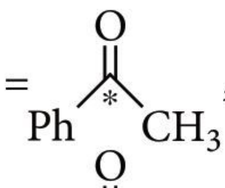
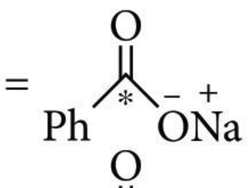
(d) Carbylamine reaction

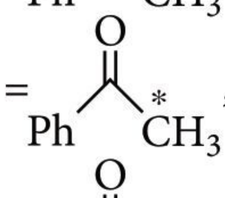
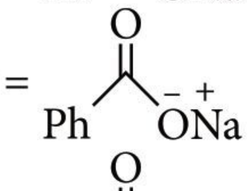
35. In the following reactions sequence,

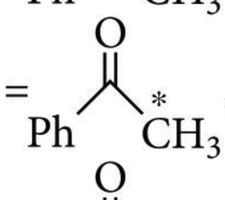
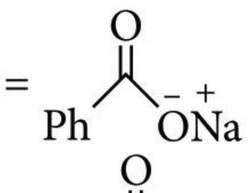


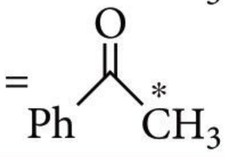
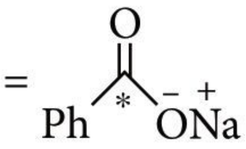
(* implies ^{13}C labelled carbon)

the correct structures of *A*, *B* and *C* are

(a) $A =$  , $B =$  , $C = CHI_3$

(b) $A =$  , $B =$  , $C = CHI_3$

(c) $A =$  , $B =$  , $C = \overset{*}{C}HI_3$

(d) $A =$  , $B =$  , $C = CH_3I$

SECTION - B

Out of 15 Questions, Attempt any 10 Questions

36. In a system : $A_{(s)} \rightleftharpoons 2B_{(g)} + 3C_{(g)}$, if the concentration of *C* at equilibrium is increased by a factor 2, it will cause the equilibrium concentration of *B* to change by

(a) two times of its original value

(b) one half of its original value

(c) $2\sqrt{2}$ times of its original value

(d) $\frac{1}{2\sqrt{2}}$ time of its original value.

37. It is desired to increase the volume of 80 cm^3 of a gas by 20% without changing pressure. To what temperature the gas should be heated if its initial temperature is 25 °C?

(a) 35.6 °C (b) 84.6 °C

(c) 630.6 °C (d) 35 °C

38. What is the weight percentage of urea solution in which 10 g of urea is dissolved in 90 g of water?

(a) 10% (b) 15% (c) 12% (d) 18%

39. A gas expands from 3 dm^3 to 5 dm^3 against a constant pressure of 3 atm. The work done during expansion is used to heat 10 moles of water at 290 K. Calculate final temperature of water.

(Specific heat of water = 4.184 J $g^{-1}K^{-1}$)

(a) 290 K (b) 290.81 K

(c) 289.19 K (d) 289.52 K

40. Which of the following pairs have both the elements showing highest oxidation states equal to $[ns + (n-1)d]$ electrons

(a) Ti and Fe (b) Cr and Co

(c) Cr and Mn (d) Co and Ni.

41. $CCl_3CH=CH_2 \xrightarrow{Cl_2 + H_2O} A$; *A* is

(a) CCl_3CHCH_2Cl (OH) (b) CCl_3CHCH_2OH (Cl)

(c) CCl_3CHCH_2 (Cl, Cl) (d) CCl_3CHCH_2 (OH, OH)

42. The incorrect statement among the following is
(a) α-*D*-glucose and β-*D*-glucose are anomers
(b) the pentaacetate of glucose does not react with hydroxylamine
(c) cellulose is a straight chain polysaccharide made up of only β-*D*-glucose units
(d) α-*D*-glucose and β-*D*-glucose are enantiomers.

43. Heavy water is manufactured
(a) by repeated electrolysis of 3% aqueous NaOH
(b) by electrolysis of water containing heavy hydrogen dissolved in it
(c) by combination of hydrogen and heavier isotope of oxygen
(d) none of the above.

44. Extraction of zinc from zinc blende is achieved by
(a) electrolytic reduction
(b) roasting followed by reduction with carbon
(c) roasting followed by reduction with another metal
(d) roasting followed by self-reduction.

45. Green chemistry means such reactions which
(a) are related to the depletion of ozone layer
(b) study the reactions in plants
(c) produce colour during reactions
(d) reduce the use and production of hazardous chemicals.

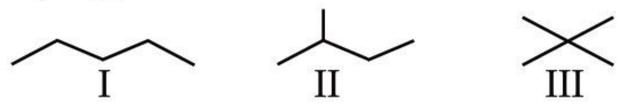
46. The nucleus of an atom can be assumed to be spherical. The radius of the nucleus of mass number A is given by $1.25 \times 10^{-13} \times A^{1/3}$ cm. Radius of atom is 1 Å. If the mass number is 64, then the fraction of the atomic volume that is occupied by the nucleus is
(a) 1.0×10^{-3}
(b) 5.0×10^{-5}
(c) 2.5×10^{-2}
(d) 1.25×10^{-13}

47. In which of the enlisted cases, Hess's law is not applicable?
(a) Determination of lattice energy
(b) Determination of resonance energy
(c) Determination of enthalpy of transformation of one allotropic form to another
(d) Determination of entropy

48. On passing 3 Ampere of electricity for 50 minutes, 1.8 g metal is deposited. The equivalent mass of metal is
(a) 20.5 (b) 25.8
(c) 19.3 (d) 30.7

49. The reaction,
$RCl + NaI \xrightarrow{\text{Acetone}} R - I + NaCl$ is known as
(a) Wurtz reaction
(b) Fittig reaction
(c) Frankland's reaction
(d) Finkelstein's reaction.

50. Following are the isomers of molecular formula for C_5H_{12}.

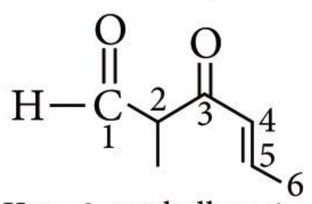


Decreasing order of their boiling point is
(a) I < II < III (b) I > II > III
(c) II > I > III (d) III > I > II

SOLUTIONS

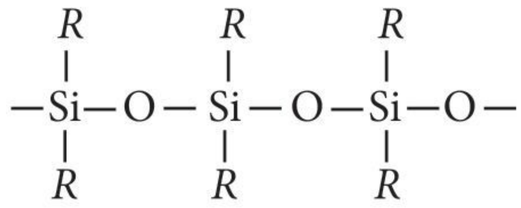
1. (b) : Total number of stereoisomers for the given compound is four. Out of which two are geometrical isomers and two are optical isomers.

2. (d) :



3-Keto-2-methylhex-4-enal

3. (b) : R_2SiO- is the repeating unit in silicone.



4. (a)

5. (d) : Heisenberg uncertainty principle can be written as,

$$\Delta x.\Delta p \geq \frac{h}{4\pi} \text{ or } \Delta x.m\Delta v \geq \frac{h}{4\pi} \Rightarrow \Delta x.\Delta v \geq \frac{h}{4\pi m}$$

Also, $\Delta p.\Delta x = \Delta E.\Delta t \Rightarrow \Delta E.\Delta t \geq \frac{h}{4\pi}$

6. (d) : Molecular orbital electronic configuration of N_2 is $\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \pi 2p_x{}^2 \approx \pi 2p_y{}^2, \sigma 2p_z{}^2$. Molecular orbital electronic configuration of O_2 is $\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_z{}^2, \pi 2p_x{}^2 \approx \pi 2p_y{}^2, \pi^* 2p_x{}^1 \approx \pi^* 2p_y{}^1$. When $N_2{}^+$ is formed from N_2, electron is removed from σ-bonding M.O. and hence, bond order decreases while when $O_2{}^+$ is formed from O_2, electron is removed from π-antibonding M.O. and hence, bond order increases.

7. (c) : Molecular solids are the substances having molecules as constituent units and having interparticle forces such as van der Waal's forces or hydrogen bonds.

18+

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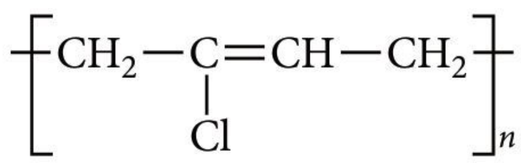
8. (c) :

Element	%	Atomic mass	Relative number of atoms	Simplest ratio of atoms
C	18.5	12	$\frac{18.5}{12} = 1.542$	1
H	1.55	1	$\frac{1.55}{1} = 1.55$	1
Cl	55.04	35.5	$\frac{55.04}{35.5} = 1.55$	1
O	24.81	16	$\frac{24.81}{16} = 1.55$	1

Therefore, empirical formula of the compound is CHClO.

9. (c) : Glucose is present in pyranose form.

10. (a) : Correct representation of neoprene is



11. (c)

12. (d) : [18]-Annulene is aromatic since it is planar and contains $(4n + 2)$ π-electrons. Although annulenes [10] and [14] also contain $(4n + 2)$ π-electrons but the crowding of hydrogens inside the ring prevents planarity and hence are not aromatic.

13. (b) : $\Lambda^{\infty}_{NH_4OH} = \Lambda^{\infty}_{NH_4Cl} + \Lambda^{\infty}_{NaOH} - \Lambda^{\infty}_{NaCl}$
$= 129.8 + 248.1 - 126.4$
$= 251.5\ ohm^{-1}cm^2mol^{-1}$

14. (c) : The size of given metals decreases whereas ionization enthalpy increases from Ti to Fe. Hence, the metallic character of the metals decreases and therefore, basicity of oxides decreases from Ti to Fe.

15. (a) : On comparison,

$$\Delta S = -\left[\frac{d(\Delta G)}{dT}\right];\ \Delta S = -\frac{d(-nFE)}{dT} = nF\left(\frac{dE}{dT}\right)$$

$$\therefore \quad \left(\frac{dE}{dT}\right) = \frac{\Delta S}{nF}$$

16. (b) : When an electron withdrawing group (like $-NO_2$, $-Cl$) is attached to the phenol ring, it stabilises the negative charge on the oxygen of phenoxide ion. Due to this reason, acidic character of phenol increases. But when an electron donating group (like $-CH_3$) is attached to the phenol ring, it destabilises the ring and hence, acidic character of phenol decreases. Thus, the correct order of acidic character is *p*-nitrophenol > *p*-chlorophenol > phenol > *o*-cresol.

17. (d)

18. (b) : We know that, $\frac{r_A}{r_B} = \frac{V/t_A}{V/t_B} = \sqrt{\frac{M_B}{M_A}}$

$$\frac{t_B}{t_A} = \sqrt{\frac{M_B}{M_A}} \Rightarrow \frac{10}{20} = \sqrt{\frac{M_B}{49}} \Rightarrow \left(\frac{10}{20}\right)^2 = \frac{M_B}{49}$$

$$\Rightarrow \frac{100}{400} = \frac{M_B}{49} \Rightarrow M_B = \frac{49 \times 100}{400} = 12.25\ u$$

19. (d) : Nucleophiles are electron rich species hence, they are Lewis bases.

20. (a)

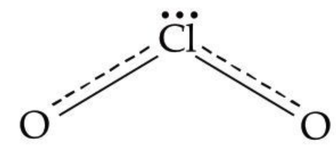
21. (a) : Spin only magnetic moment = $\sqrt{n(n+2)}$ B.M.
where, n = number of unpaired electrons.
$\sqrt{n(n+2)} = 2.84$ B.M. (given)
Hence, $n = 2$
In octahedral complex, a strong field ligand results in a low spin complex.
Thus, d^4 configuration has two unpaired electrons.

22. (d) : In a simple cubic system, number of atoms, $a = 2r$

$$\therefore \quad \text{Packing fraction} = \frac{\text{Volume occupied by one atom}}{\text{Volume of unit cell}}$$

$$= \frac{\frac{4}{3}\pi r^3}{a^3} = \frac{\frac{4}{3}\pi r^3}{(2r)^3} = \frac{\pi}{6}$$

23. (a) : The odd electron of Cl_2 is delocalised thus, ClO_2 does not dimerise.



24. (a) : As we move from left to right in a period the basic character of oxides of *s*- and *p*-block elements decreases while their acidic character increases. The basic character of oxides of *d*-block elements is, lower than alkali and alkaline earth metals. Thus, Na_2O is most basic followed by MgO and Al_2O_3 while CuO is least basic.

25. (a) : The acid used is H_2PtCl_6. It is a solution of platinic chloride, $PtCl_4$ in conc.HCl
$2RNH_2 + H_2[PtCl_6] \longrightarrow [RNH_3]^+{}_2[PtCl_6]^{2-}$
Chloroplatinates on ignition leave a residue of metallic Pt. This reaction is employed in determining molecular weight of amines.

26. (a)

27. (a) : From experiments 1 and 2, $[A]$ is kept constant, $[B]$ is doubled, rate is doubled. Thus, rate $\propto [B]$.
From experiments 2 and 3, $[B]$ is kept constant, $[A]$ is tripled, rate becomes 9 times so, rate $\propto [A]^2$.
Overall rate $\propto [A]^2[B]$ or rate $= k[A]^2[B]$

28. (a) : In redox reaction, oxidation and reduction takes place simultaneously.

$$\overset{+2+4-2}{CaCO_3} \longrightarrow \overset{+2-2}{CaO} + \overset{+4-2}{CO_2}$$

Since, in this reaction, no oxidation or reduction takes place thus, it is not a redox reaction.

29. (a) : Di-*tert*-butyl ether cannot be made by Williamson's synthesis, since *tert*-alkyl halides prefer to undergo elimination rather than substitution, *i.e.*,

$$CH_3-\underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{C}}-Br + CH_3-\underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{C}}-O^-Na^+ \xrightarrow[-NaBr]{\Delta}$$

$$CH_3-\underset{}{\overset{\overset{CH_3}{|}}{C}}=CH_2 + CH_3-\underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{C}}-OH$$

30. (c) : $K_f = \dfrac{RT_f^{\,2}}{1000\ell_f}$

Here, $R = 2$ cals, $T_f = 0 + 273$ K, $\ell_f = 80$ cals

$$K_f = \frac{2\times(273)^2}{1000\times 80} = 1.86$$

31. (d) : Both $Be(OH)_2$ and $Zn(OH)_2$ are amphoteric in nature.

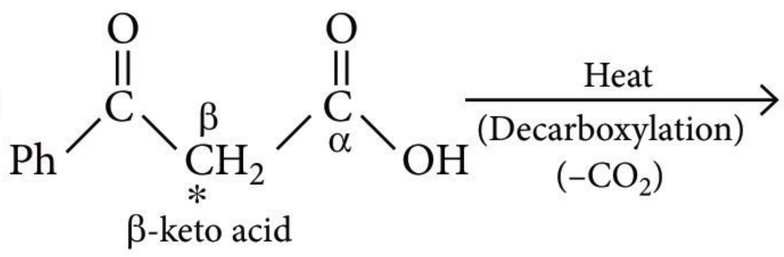
32. (d) : LABS (Linear alkylbenzene sulphonate detergents are biodegradable.

33. (a)

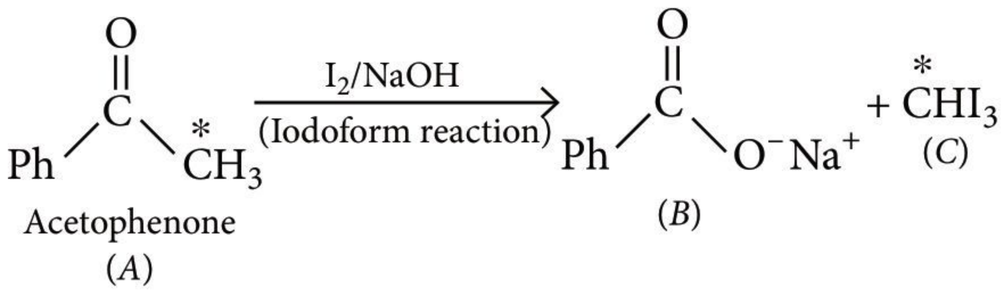
34. (a) : $\underset{\text{Acetamide}}{CH_3-\overset{\overset{O}{\|}}{C}-NH_2} + Br_2 + 4KOH \xrightarrow[\Delta]{\text{Hoffmann hypobromamide reaction}} CH_3NH_2 + 2KBr + K_2CO_3 + 2H_2O$

Methylamine

35. (c) :



β-keto acid



Acetophenone
(*A*)

(*B*)

36. (d) : $A_{(s)} \rightleftharpoons 2B_{(g)} + 3C_{(g)}$

$\therefore \quad K_c = [C]^3[B]^2$;

If $[C]$ becomes twice, let conc. of B becomes B', then

$K_c = [2C]^3[B']^2$ or $[C]^3[B]^2 = [2C]^3[B']^2$

$$\therefore \quad \frac{[B']}{[B]} = \sqrt{\frac{1}{8}} = \frac{1}{2\sqrt{2}}$$

37. (b) : The desired increase in the volume of gas is

$$20\% \text{ of } 80\ \text{cm}^3 = \frac{80}{100} \times 20 = 16\ \text{cm}^3$$

Thus, the final volume of the gas is $80 + 16 = 96\ \text{cm}^3$

Now, $V_1 = 80\ \text{cm}^3$, $V_2 = 96\ \text{cm}^3$

$T_1 = 25°\text{C} = 298\ \text{K}$, $T_2 = ?$

Applying Charles' law, we get

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}; \quad T_2 = \frac{V_2 T_1}{V_1} = \frac{96\ \text{cm}^3 \times 298\ \text{K}}{80\ \text{cm}^3} = 357.6\ \text{K}$$

$= 357.6 - 273 = 84.6\ °\text{C}$

38. (a) : Weight percentage of urea

$$= \frac{\text{Weight of urea}}{\text{Weight of solution}} \times 100$$

$$= \frac{10}{90 + 10} \times 100$$

= 10% urea solution (w/W)

39. (b) : Work done is against constant external pressure, hence, process is irreversible.

$w = -P\Delta V$, $\Delta V = V_2 - V_1 = 5 - 3 = 2\ \text{dm}^3$,

$\Delta V = 2 \times 10^{-3}\ \text{m}^3$

$P = 3\ \text{atm} = 3 \times 1.013 \times 10^5\ \text{N m}^{-2}$

$\therefore \quad w = -3 \times 1.013 \times 10^5 \times 2 \times 10^{-3} = -607.8\ \text{J}$

Expansion work done $= -607.8\ \text{J}$

Work is used to heat water therefore,

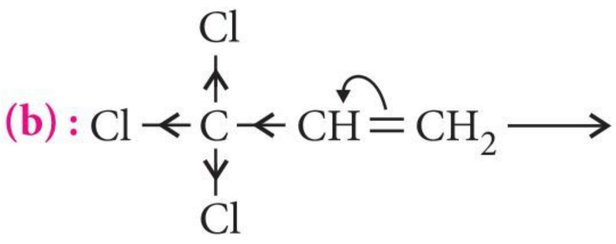
$-w = q = m \times C \times \Delta T$,

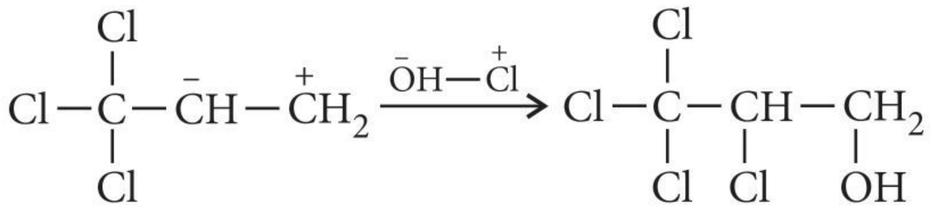
$607.8 = 10 \times 18 \times 4.184 \times 18 \times \Delta T$ or $\Delta T = 0.81\ \text{K}$

$\therefore$ Final temperature of water $= 290 + 0.81 = 290.81\ \text{K}$

40. (c) : Cr and Mn show the highest oxidation states +6 and +7 respectively.

41. (b) :





42. (d)

43. (a) : Heavy water is manufactured by repeated electrolysis of water (containing a little NaOH).

44. (b) **45. (d)**

46. (d) : Radius of nucleus $= 1.25 \times 10^{-13} \times (64)^{1/3}$

$= 5 \times 10^{-13}$ cm

Radius of atom $= 1\ \text{Å} = 1 \times 10^{-8}$ cm

$$\text{Fraction of volume} = \frac{\text{Volume of nucleus}}{\text{Volume of atom}}$$

$$= \frac{\frac{4}{3}\pi\left(5 \times 10^{-13}\right)^3}{\frac{4}{3}\pi\left(1 \times 10^{-8}\right)^3} = \frac{125 \times 10^{-39}}{10^{-24}} = 1.25 \times 10^{-13}$$

47. (d) : Hess's law cannot be used for the determination of entropy.

48. (c) : $w_{\text{metal}} = \frac{E \times I \times t}{96500} = \frac{E \times 3 \times 50 \times 60}{96500}$

$$E = \frac{96500 \times w}{3 \times 50 \times 60} = \frac{96500 \times 1.8}{3 \times 50 \times 60} = 19.3$$

49. (d)

50. (b) : The *n*-alkanes have the most extended structure and larger surface area in comparison to branched chain isomers having compact structure (as the shape approaches that of a sphere in the branched chain isomers). Thus, intermolecular forces are weaker in branched chain isomers, therefore, they have lower boiling points in comparison to straight chain isomers *i.e.*, higher the branching, lower the boiling point, hence, the order is : I > II > III.

JEE 2021 PRACTICE PAPER ADVANCED

PAPER - I

Section 1 (Maximum Marks : 18)

- ***This section contains SIX (06) questions.***
- ***Each question has FOUR options. ONLY ONE of these four options is the correct answer.***
- ***For each question, choose the option corresponding to the correct answer.***
- ***Answer to each question will be evaluated according to the following marking scheme :***

Full Marks :	***+3***	***If ONLY the correct option is chosen.***
Zero Marks :	***0***	***If none of the options is chosen (i.e. the question is unanswered).***
Negative Marks :	***–1***	***In all other cases.***

1. $H_4P_4O_{12}$ (tetrametaphosphoric acid) and $H_6P_4O_{13}$ (tetrapolyphosphoric acid) have same

(a) no. of P—O—P bonds
(b) no. of P—O—H bonds
(c) no. of P═O bonds
(d) all of these.

2. Consider the following reaction to prepare labile thiosulphate :

$$SO_3^{2-} + {}^{35}_{16}S \xrightarrow{\text{Boil}} {}^{35}_{16}SSO_3^{2-}$$

($^{35}_{16}S$ = labile sulphur, S = normal sulphur)

If thiosulphate so formed is decomposed by treatment with dil. H_2SO_4 or dil. HCl then :

(a) $SO_2 + {}^{35}_{16}S + H_2O$ are produced

(b) ${}^{35}_{16}S_2 + S + H_2O$ are produced

(c) $SO_2 + {}^{35}_{16}SO_2 + S + {}^{35}_{16}S + H_2O$ are produced

(d) $SO_2 + {}^{35}_{16}SO_2 + S + H_2O$ are produced

3. The value of $\frac{t_{0.875}}{t_{0.50}}$, for n^{th} order reaction is

(a) $2^{(2n-2)}$ (b) $2^{(2n-2)} - 1$

(c) $\frac{8^{n-1}-1}{2^{n-1}-1}$ (d) none of these.

4. A metal ion shows different co-ordination number with different oxidation state. With same ligand in one oxidation state it does not show any isomerism but in other oxidation state with same ligand it shows isomerism, from two of them choose the compound with same ligand which has $d_{x^2-y^2}$ at higher energy than d_{z^2} orbital of metal :

(a) *bis*(glycinato) platinum (II)
(b) *bis*(ethylenediammine) platinum (II) ion
(c) *tris*(glycinato) platinum (IV) ion
(d) *tris*(ethylenediammine) platinum (IV) ion

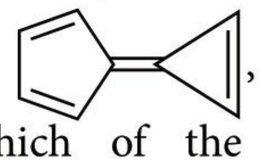
5. For the given reaction,

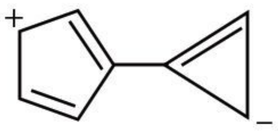
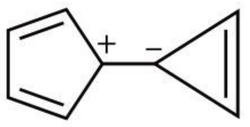
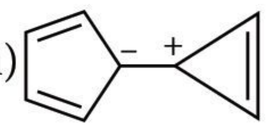
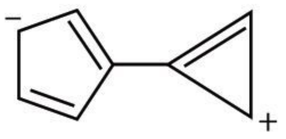
$$HO-CH_2-CH_2-CH_2-CH_2Cl \xrightarrow{\bar{O}H} (A)$$

which of the following statements is true?

(i) (*A*) is butane-1, 4-diol.
(ii) (*A*) is tetrahydrofuran.
(iii) (*A*) is prepared by S_N1 reaction.
(iv) (*A*) is prepared by intramolecular S_N2 reaction.

(a) (i) only (b) (ii) and (iv) only
(c) (i) and (iv) only (d) (ii) and (iii) only

6. A compound  , shows a large dipole moment. Which of the following resonance structures can be used to adequately explain this observation?

(i) 
(ii) 
(iii) 
(iv) 

(a) (i) only (b) (iii) and (iv) only
(c) (ii) and (iii) only (d) (iv) only

Section 2 (Maximum Marks : 24)

- ***This section contains SIX (06) questions.***
- ***Each question has FOUR options. ONE OR MORE THAN ONE of these four option(s) is (are) correct answer(s).***

- ***For each question, choose the option(s) corresponding to (all) the correct answer(s).***
- ***Answer to each question will be evaluated according to the following marking scheme :***

Full Marks :	***+4***	***If only (all) the correct option(s) is (are) chosen.***
Partial Marks :	***+3***	***If all the four options are correct but ONLY three options are chosen.***
Partial Marks :	***+2***	***If three or more options are correct but ONLY two options are chosen, both of which are correct.***
Partial Marks :	***+1***	***If two or more options are correct but ONLY one option is chosen and it is a correct option.***
Zero Marks :	***0***	***If none of the options is chosen (i.e. the question is unanswered).***
Negative Marks :	***–2***	***In all other cases.***

7. Which is not correct?

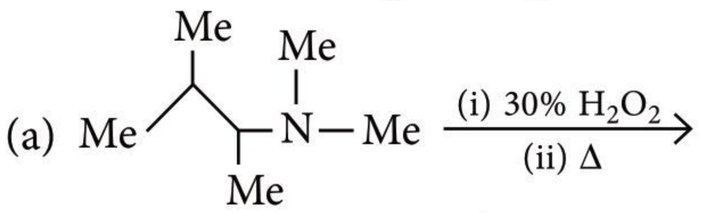
(a) $Ge(OH)_2$ is amphoteric.

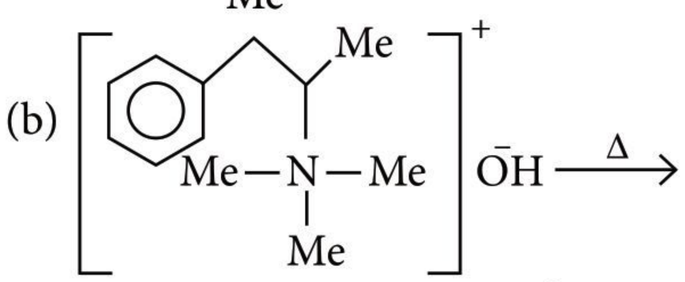
(b) $GeCl_2$ is more stable than $GeCl_4$.

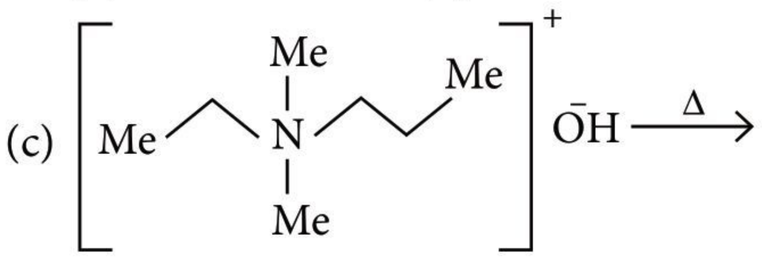
(c) GeO_2 is weakly acidic.

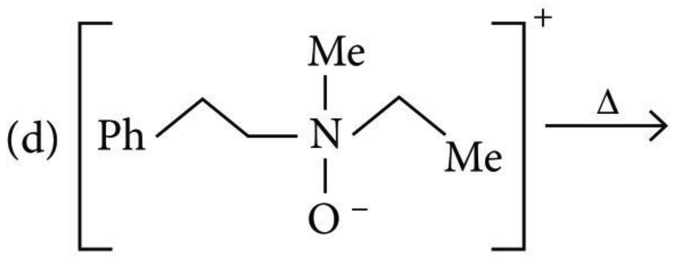
(d) $GeCl_4$ in HCl forms $[GeCl_6]^{2-}$ ion.

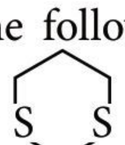
8. Which of the following would give Hoffmann alkene?

(a) 

(b) 

(c) 

(d) 

9. Which of the following statements is false about 1,3-dithiane, 

?

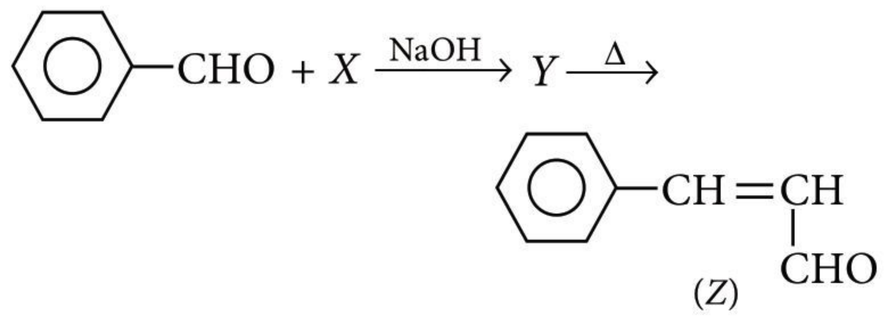
(a) It can react with *R*Li.

(b) It can be alkylated by $CH_3CH_2CH_2Br$.

(c) It can be alkylated by Me_2CHX.

(d) It can be used for preparing aldehydes and ketones.

10. Which of the following statement(s) is/are correct for the reaction given below?



(a) It is an example of aldol condensation.

(b) X = HCHO, Y = Acetal

(c) $X = CH_3CHO$,
Y = 3-Hydroxy-3-phenyl propanaldehyde

(d) It is Claisen-Schmidt condensation.

11. The hemiacetal form of glucose is indicated by

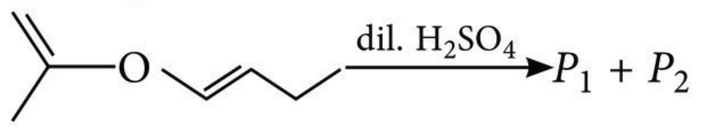
(a) reaction with $(CH_3CO)_2O$

(b) oxidation with Tollens' reagent

(c) reduction with HI/P

(d) glycoside formation.

12. In the given reaction,



P_1 and P_2 products are identified by

(a) Tollens' reagent (b) 1% alkaline $KMnO_4$

(c) bromine-water test (d) none of these.

Section 3 (Maximum Marks : 24)

- ***This section contains SIX (06) questions. The answer to each question is a NUMERICAL VALUE.***
- ***For each question, enter the correct numerical value of the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer. If the numerical value has more than two decimal places, truncate/round-off the value to TWO decimal places.***
- ***Answer to each question will be evaluated according to the following marking scheme :***

Full Marks :	***+4***	***If ONLY the correct numerical value is entered.***
Zero Marks :	***0***	***In all other cases.***

13. The reaction, *cis*-$X \underset{k_b}{\overset{k_f}{\rightleftharpoons}}$ *trans*-X is first order in both directions. At 25°C, the equilibrium constant is 0.10 and the rate constant, $k_f = 3 \times 10^{-4}\ s^{-1}$. In an experiment starting with the pure *cis*-form, how long (in sec) would it take for half of the equilibrium amount of the *trans*-isomer to be formed?

14. What will be the resultant pH when 200 mL of an aqueous solution of HCl (pH = 2) is mixed with 300 mL of an aqueous solution of NaOH (pH = 12.0)?

15. A Duma's bulb full of air weighs 22.567 g at 20°C and 755 mm pressure. Full of vapours of a substance at 120 °C and 755 mm pressure weighs 22.8617 g. The capacity of bulb is 200 mL. Find the molecular weight of substance. (The density of air is 0.00129 g/mL.)

16. A plant virus was found to consist of uniform cylindrical particles 100 Å in diameter and 4000 Å long. The virus has a specific volume 0.314 $cm^3\ g^{-1}$. If the virus particle is considered to be one molecule, then its molecular weight is $x \times 10^7$ g mol^{-1}. The value of x is _____.

17. BI_3 is a symmetrical planar molecule, all the B — I bonds lie at 120° of each other. The distance between the I atoms is 3.54Å. The radius of covalently bonded I atom is 1.33Å. The covalent radius of boron (in Å) is _____.

18. 1 mole of an ideal gas $A(C_{v,m} = 3R)$ and 2 moles of an ideal gas B are $\left(C_{v,m} = \frac{3}{2}R\right)$ taken in a container and expanded reversibly and adiabatically from 1 litre to 4 litre starting from initial temperature of 320 K. ΔU for the process is — xR. The value of x is

PAPER - II

Section 1 (Maximum Marks : 18)

- ***This section contains SIX (06) questions.***
- ***The answer to each question is a SINGLE DIGIT INTEGER ranging from 0 to 9, BOTH INCLUSIVE.***
- ***For each question, enter the correct integer corresponding to the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.***
- ***Answer to each question will be evaluated according to the following marking scheme :***

Full Marks :	***+3***	***If ONLY the correct integer is entered.***
Zero Marks :	***0***	***If the question is unanswered;***
Negative Marks :	***–1***	***In all other cases.***

1. The atomic masses of He and Ne are 4 and 20 amu respectively. The value of the de Broglie wavelength of He gas at –73 °C is '*M*' times that of the de Broglie wavelength of Ne at 727 °C. The value of '*M*' is

2. Calculate percentage of S_N1 product if (*R*)-2-chloro butane on reaction with $NaOH/H_2O$ and acetone gives 98 % inverted product.

3. How many isomers are possible for disubstituted borazole $B_3N_3H_4X_2$?

4. For how many of the following, the apparent weight increases by applying magnetic field? NO, NO_2, O_2, $K_3[Fe(CN)_6]$, KO_2, $MnSO_4$, $NiSO_4$, $CuSO_4$, $ZnSO_4$

5. Assuming covalent radii to be additive property; calculate the iodine-iodine distances (in Å) in *p*-diiodobenzene. The benzene ring is regular hexagon and each C—I bond lies on a line passing through the centre of hexagon. The C—C bond length in C_6H_6 is 1.40 Å and covalent radius of iodine and carbon atoms are 1.33 Å and 0.77 Å. Also neglect different overlapping effect.

6. During the electrolysis of conc. H_2SO_4, it was found that $H_2S_2O_8$ and O_2 were liberated in a molar ratio of 3 : 1. If moles of H_2 in terms of moles of $H_2S_2O_8$ is $a : b$ then the value of $3 \times a/b$ is

Section 2 (Maximum Marks : 24)

- ***This section contains SIX (06) questions.***
- ***Each question has FOUR options. ONE OR MORE THAN ONE of these four option(s) is (are) correct answer(s).***
- ***For each question, choose the option(s) corresponding to (all) the correct answer(s).***
- ***Answer to each will be evaluated according to the following marking scheme :***

Full Marks :	***+4***	***If only (all) the correct option(s) is (are) chosen;***
Partial Marks :	***+3***	***If all the four options are correct but ONLY three options are chosen;***
Partial Marks :	***+2***	***If three or more options are correct but ONLY two options are chosen, and both of which are correct;***
Partial Marks :	***+1***	***If two or more options are correct but ONLY one option is chosen and it is a correct option;***
Zero Marks :	***0***	***If none of the options is chosen (i.e., the question is unanswered);***
Negative Marks :	***–2***	***In all other cases.***

7. H_2 gas is mixed with air at 25°C under pressure of one atmosphere and exploded in a closed vessel. The enthalpy of the reaction
$H_{2(g)} + 1/2O_{2(g)} \longrightarrow H_2O_{(g)}$ at constant volume, $\Delta U_{298} = -240.6$ kJ and C_v for H_2O vapour and N_2 in the temperature range 298 K and 3,200 K are 39.1 J K^{-1} and 26.4 J K^{-1}, respectively. What will be the explosion temperature under adiabatic conditions?

(a) 2700 K (b) 2916 K
(c) 3020 K (d) 5120 K

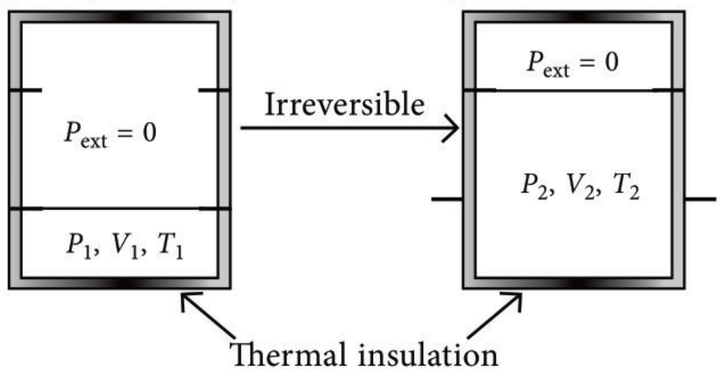
8. Mark the incorrect statement(s).
(a) Potassium dichromate oxidises a secondary alcohol into a ketone.
(b) Potassium permanganate is a weaker oxidising agent than potassium dichromate.
(c) Potassium dichromate oxidises a secondary alcohol into aldehyde.
(d) Alkaline $KMnO_4$ solution oxidises tertiary alcohol to a mixture of a ketone and an acid.

9. $MeCOOEt \xrightarrow[(ii)\ HNO_2\ (iii)\ OH^-]{(i)\ NH_2NH_2} (B) \xrightarrow{MeOH} (C)$
Which of the following statements are correct about the given reactions sequence?
(a) The compounds (*B*) and (*C*), respectively, are Me — N = C = O and MeNHCOOMe.
(b) The compounds (*B*) and (*C*), respectively, are Et — N = C = O and $MeNH_2$.
(c) The reaction proceeds via the formation of acyl nitrene ($MeC\ddot{O}\ddot{N}$:) as the intermediate species.
(d) The reaction proceeds via the formation of acyl nitrene ($EtC\ddot{O}\ddot{N}$:) as the intermediate species.

10. 4, 4′-Dinitrodiphenyl is obtained when
(a) 4-nitrochlorobenzene is heated with Na/ether
(b) 4-nitroiodobenzene is heated with copper powder in a sealed tube
(c) diphenyl is heated with a mixture of conc. HNO_3 + conc. H_2SO_4
(d) nitrobenzene is treated with 4-nitro-chlorobenzene in presence of anhyd. $AlCl_3$.

11. Identify compound(s) in which gauche conformer is more stable than staggered.
(a) 1, 2-Difluoroethane (b) Chloropropane
(c) Ethylene glycol (d) Succinic acid

12. An ideal gas in a thermally insulated vessel at internal pressure = P_1, volume = V_1 and absolute temperature = T_1 expands irreversibly against zero external pressure, as shown in the diagram. The final internal pressure, volume and absolute temperature of gas are P_2, V_2 and T_2, respectively. For this expansion,



(a) $q = 0$ (b) $T_2 = T_1$
(c) $P_2V_2 = P_1V_1$ (d) $P_2V_2^{\gamma} = P_1V_1^{\gamma}$

Section 3 (Maximum Marks : 24)

- ***This section contains SIX (06) questions. The answer to each question is a NUMERICAL VALUE.***
- ***For each question, enter the correct numerical value of the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer. If the numerical value has more than two decimal places, truncate/round-off the value to TWO decimal places.***
- ***Answer to each question will be evaluated according to the following marking scheme :***

Full Marks : ***+4*** ***If ONLY the correct numerical value is entered;***
Zero Marks : ***0*** ***In all other cases.***

13. A given sample of milk turns sour at room temperature (20 °C) in 64 hours. In a refrigerator at 3 °C, milk can be stored three times as long before it sours. How long (in hr) will it take milk to sour at 40 °C?

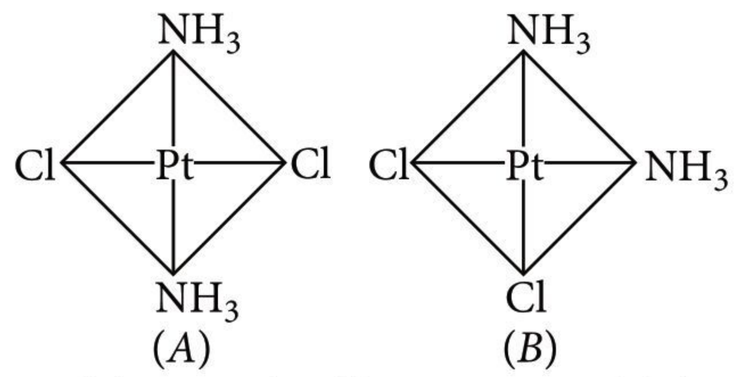
14. Ammonia forms complexes with Ag^+ ion according to the following reactions :
(i) $[Ag(H_2O)_2]^+_{(aq)} + NH_{3(aq)} \rightleftharpoons [Ag(NH_3)(H_2O)]^+_{(aq)} + H_2O_{(l)}$
(ii) $[Ag(NH_3)(H_2O)]^+_{(aq)} + NH_{3(aq)} \rightleftharpoons [Ag(NH_3)_2]^+_{(aq)} + H_2O_{(l)}$
The equilibrium constants for the reaction (i) and (ii) are 2.0×10^3 and 8.3×10^3 respectively, then the equilibrium constant of the following reaction is $x \times 10^6$. The value of x is _____.
$[Ag(H_2O)_2]^+_{(aq)} + 2NH_{3(aq)} \rightleftharpoons [Ag(NH_3)_2]^+_{(aq)} + 2H_2O_{(l)}$

15. An acidic solution of Cu^{2+} salt containing 0.4 g of Cu^{2+} is electrolysed until all the copper is deposited. The electrolysis is continued for seven more minutes with volume of solution kept at 100 mL and the current at 1.2 amp. Calculate the volume (in mL) of gases evolved at NTP during the entire electrolysis.

16. When cells of skeletal vacuoles of a frog were placed in a series of NaCl solutions of different concentrations at 25 °C, it was observed micro-scopically that they remained unchanged in 0.7% solution, shrank in more concentrated and swelled in more dilute solutions. Water in 0.7% salt solution freezes at –0.406 °C. What is the osmotic pressure (in atm) of the cell cytoplasm at 25 °C?
(K_f for water = 1.86 K kg mol^{-1})

17. If for the cell, $Zn(s) + Cu^{2+}(aq) \rightleftharpoons Cu(s) + Zn^{2+}_{(aq)}$ entropy change $\Delta S°$ is 94.6 J K^{-1} mol^{-1}, then temperature coefficient of the e.m.f of a cell is $x \times 10^{-4}$ V K^{-1}. The value of x is _____.

18. The platinum-chlorine distance has been found to be 2.32 Å in several crystalline compounds. This value applies to both the given compounds *A* and *B* :

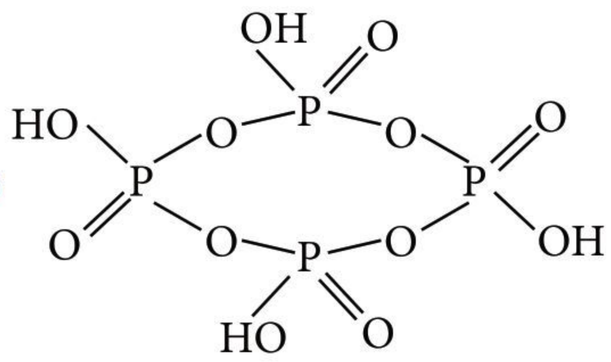


Cl — Cl distance (in Å) in compound (*B*) is _____.

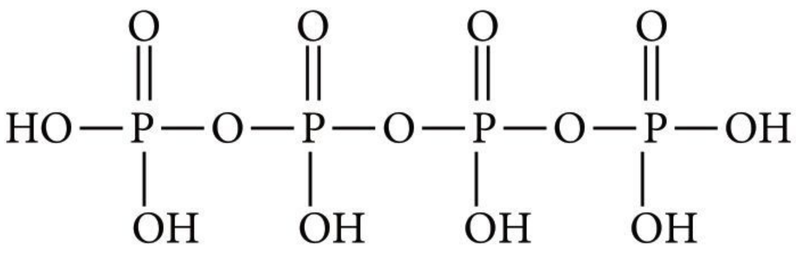
SOLUTIONS

PAPER - I

1. (c) :

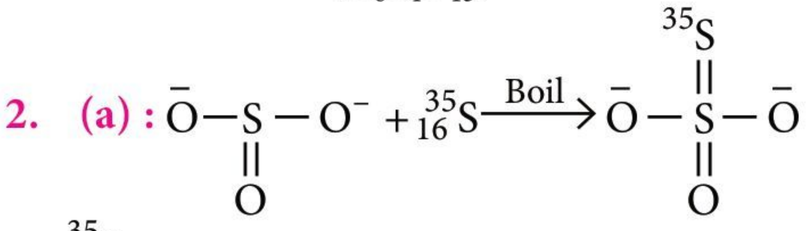


Tetrametaphosphoric acid
$(H_4P_4O_{12})$



Tetrapolyphosphoric acid
$(H_6P_4O_{13})$

2. (a) :



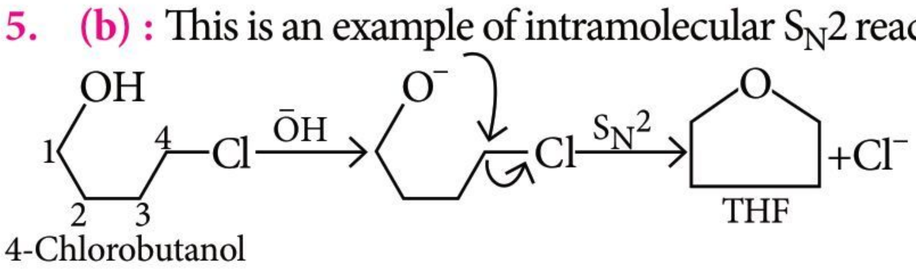
3. (c) : $kt = \frac{1}{n-1}\left[\frac{1}{[A]_t^{n-1}} - \frac{1}{[A]_0^{n-1}}\right]$

$$kt_{0.50} = \frac{1}{n-1}\left[\frac{2^{n-1}-1}{[A]_0^{n-1}}\right],\ kt_{0.875} = \frac{1}{n-1}\left[\frac{8^{n-1}-1}{[A]_0^{n-1}}\right]$$

$$\frac{t_{0.875}}{t_{0.50}} = \frac{8^{n-1}-1}{2^{n-1}-1}$$

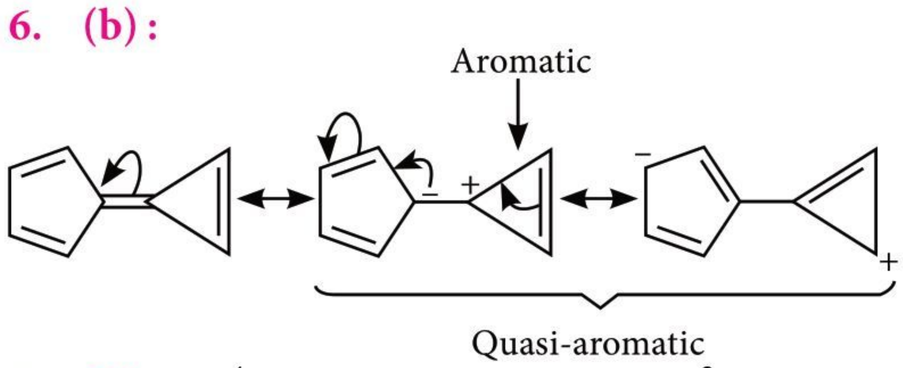
4. (b) : With glycinato ligand, Pt^{2+} and Pt^{4+} both show isomerism but with ethylene diamine, Pt^{2+} does not show but Pt^{4+} show isomerism. In $[Pt(en)_2]^{2+}$, Pt^{2+} is dsp^2 hybrid in square planar splitting $d_{x^2-y^2}$ has higher energy in comparison of d_{z^2} but in $[Pt(en)_3]^{4+}$, $d_{x^2-y^2}$ and d_{z^2} are at same energy level.

5. (b) : This is an example of intramolecular S_N2 reaction.



4-Chlorobutanol

6. (b) :

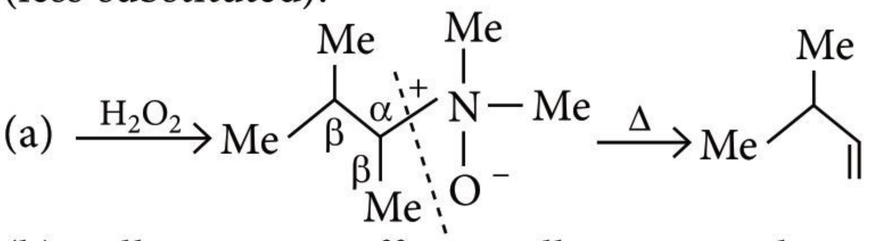


Quasi-aromatic

7. (b) : Ge^{4+} is more stable than Ge^{2+}, thus $GeCl_4$ is more stable than $GeCl_2$.

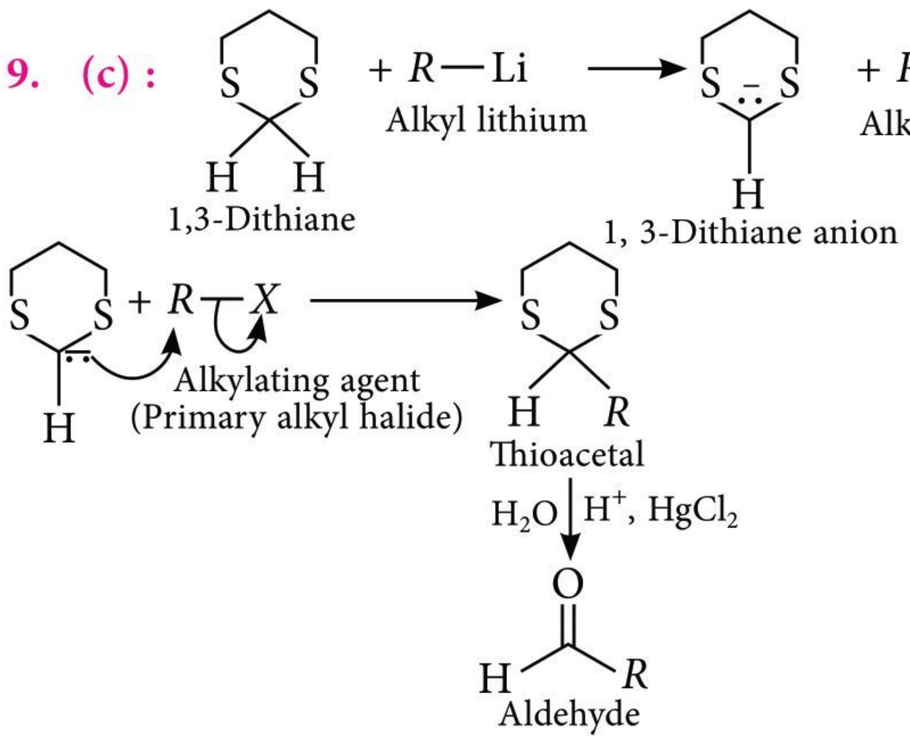
8. (a, c) :

(a) The oxidation of 3° amine to amine oxide followed by Cope reaction on heating gives Hoffmann alkene (less substituted).

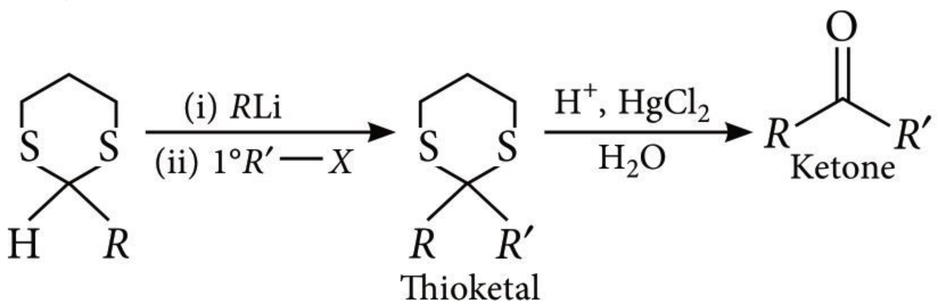


(b) will not give Hoffmann alkene. Benzylic H - atom is more acidic due to (–*I*) effect of Ph.
(c) will give Hoffmann alkene $CH_2 = CH_2$.
(d) will not give Hoffmann alkene (Cope reaction).

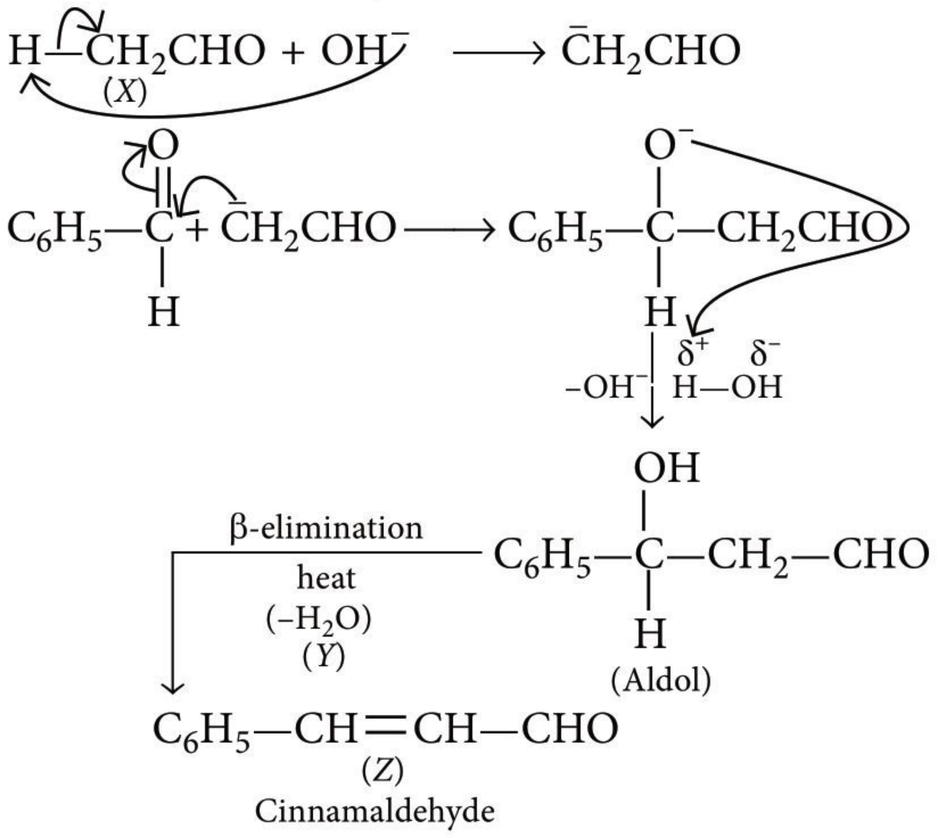
9. (c) :



Alternatively, thioacetal can be alkylated once more to give a thioketal.



10. (a, c) : $NaOH_{(aq.)} \rightleftharpoons Na^+ + OH^-$



11. (a, d) : Glucose $\xrightarrow{\text{anhydride, pyridine}}$ Pentaacetate derivative

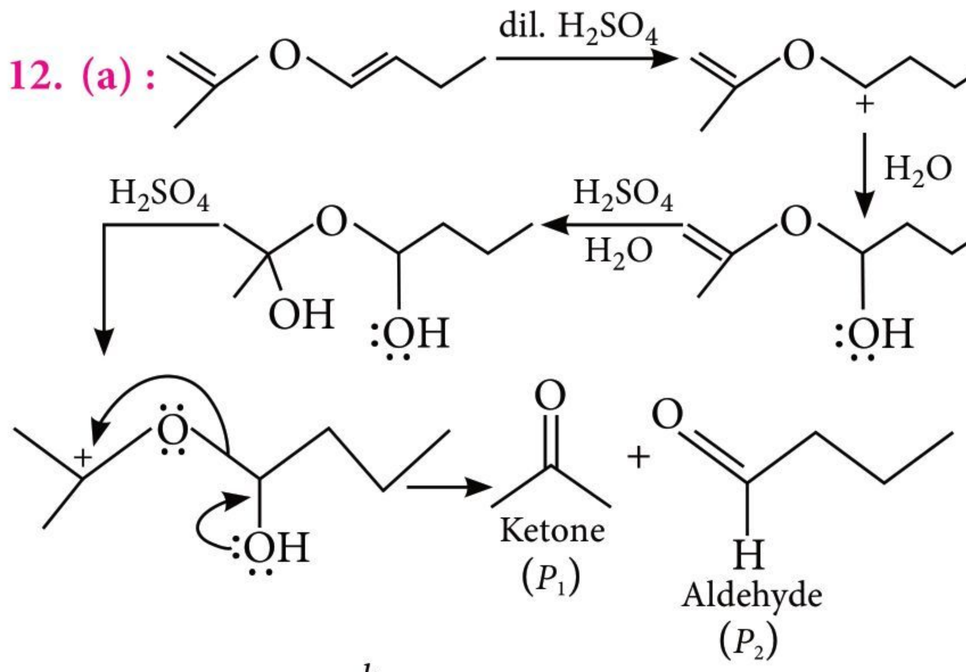
Glucose $\xrightarrow{NH_2OH}$ Form oxime

Pentaacetate derivative $\xrightarrow{NH_2OH}$ No reaction

Confirms cyclic structure

Glycoside is functionally acetal which is formed from hemiacetal.

12. (a) :



13. (210) : $cis\text{-}X \underset{k_b}{\overset{k_f}{\rightleftharpoons}} trans\text{-}X$

Initial	a	0
at time t	$a - x$	x
at eqm	$a - x_e$	x_e

$$K_{(eq)} = \frac{k_f}{k_b}; k_b = \frac{3\times10^{-4}}{0.1} = 3\times10^{-3}$$

As we know $(k_f + k_b) = \frac{1}{t}\ln\left(\frac{x_e}{x_e - x}\right)$

Given, $x = \frac{x_e}{2}$ $\therefore$ $(k_f + k_b) = \frac{1}{t}\ln 2$

or $(3 \times 10^{-4} + 3 \times 10^{-3}) = \frac{0.693}{t}$

$\therefore$ t = 210 sec

14. (11.302) : pH of HCl = 2 $\therefore$ $[H_3O^+] = 10^{-2}$M

Moles of H^+ ions in 200 mL of 10^{-2} M HCl

$= \frac{10^{-2}}{1000} \times 200 = 2 \times 10^{-3}$

pH of NaOH = 12

$\therefore$ $[H^+] = 10^{-12}$ or $[OH^-] = 10^{-2}$

Moles of OH^- ions in 300 mL of 10^{-2} M NaOH

$= \frac{10^{-2}}{1000} \times 300 = 3\times10^{-3}$

Moles of OH^- left in 500 mL of solution after mixing

$= 3 \times 10^{-3} - 2 \times 10^{-3} = 1 \times 10^{-3}$

Molar concentration of OH^- in resulting solution

$= \frac{1\times10^{-3}}{500} \times 1000 = 2\times10^{-3}$ M

pOH = $-\log(2 \times 10^{-3}) = 2.698$

pH = 14 – 2.698 = 11.302

15. (86.64) : Assume weight of bulb = w'

Wt. of air in bulb (w) = (22.567 – w')g

Pressure of air = $\frac{755}{760}$ atm

Volume of air = $\frac{200}{1000}$ litre

T = 293 K

Mol.wt. of air = 0.00129 × 22400 = 28.90 g

Using, $PV = \frac{w}{m}RT$ for air

$$\frac{755}{760} \times \frac{200}{1000} = \frac{(22.567 - w')}{28.90} \times 0.0821 \times 293$$

$\therefore$ w' = 22.3282 g

Wt. of vapours = 22.8617 – 22.3282 = 0.5335 g

$$P_{\text{vapour}} = \frac{755}{760} \text{ atm}$$

Volume of vapours = 200 mL

T = 393 K

Again by, $PV = \frac{w}{m}RT$

$$\frac{755}{760}\times\frac{200}{1000}=\frac{0.5335}{m}\times 0.0821\times 393$$

$$m = 86.64 \text{ u}$$

16. (6.02) : Volume of cylindrical particle (V)

$$= \pi r^2 h = (3.14)\left(\frac{100\,\text{Å}}{2}\right)^2 (4000\,\text{Å})$$

$$= 3.14\times 10^7\ (\text{Å})^3 = 3.14\times 10^{-17}\ \text{cm}^3$$

$\because$ The specific volume of virus = 0.314 $\text{cm}^3\ \text{g}^{-1}$ (given)

If the volume is 3.14×10^{-17} cm^3, then weight per molecule is

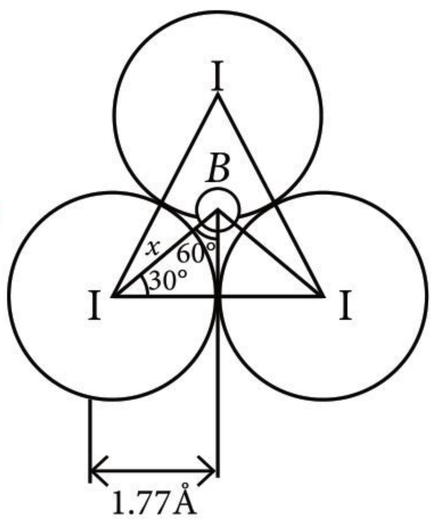
$$=\left(\frac{1}{0.314\ \text{cm}^3\text{g}^{-1}}\right)(3.14\times 10^{-17}\,\text{cm}^3) = 10^{-16}\,\text{g molecule}^{-1}$$

$\therefore$ Molecular weight of virus =

$$(10^{-16}\ \text{g molecule}^{-1})\left(\frac{6.02\times 10^{23}\ \text{molecules}}{1\ \text{mol}}\right)$$

$$= 6.02\times 10^7\ \text{g mol}^{-1}$$

17. (0.71) :



$$x = \frac{1.77}{\sin 60^\circ} = 2.04\ \text{Å}$$

$$r_B = (2.04\ \text{Å}) - (1.33\ \text{Å}) = 0.71\ \text{Å}$$

18. (960): Average $C_{v,m} = \dfrac{n_1 C_{v,m_1} + n_2 C_{v,m_2}}{n_1 + n_2} = 2R$ ...(i)

For adiabatic process, $dU = dw$

$$n_1 C_{v,m_1} dT + n_2 C_{v,m_2} dT = -(n_1 RT + n_2 RT)\times\frac{dV}{V}$$

$$\frac{dT}{T} = -\frac{R}{\text{Average } C_{v,m}}\left(\frac{dV}{V}\right)$$

On substituting the value of average $C_{v,m}$ from eqn (i), then on integration, we get

$$\ln\frac{T_2}{T_1} = -\frac{1}{2}\ln\left(\frac{V_2}{V_1}\right) \Rightarrow T_2 = 320\times\left(\frac{1}{4}\right)^{1/2} = 160\ \text{K}$$

$$\Delta U = (n_1 C_{v,m_1} + n_2 C_{v,m_2})\Delta T$$

$$=\left(1\times 3R + 2\times\frac{3}{2}R\right)(160-320) = -960\ R$$

PAPER - II

1. (5) : $\lambda = \dfrac{h}{\sqrt{2mK.E.}}$

$$\frac{\lambda_{He}}{\lambda_{Ne}} = \sqrt{\frac{m_{Ne}(K.E.)_{Ne}}{m_{He}(K.E.)_{He}}} \quad ...(i)$$

$$\frac{m_{Ne}}{m_{He}} = \frac{20}{4} = 5 \quad ...(ii)$$

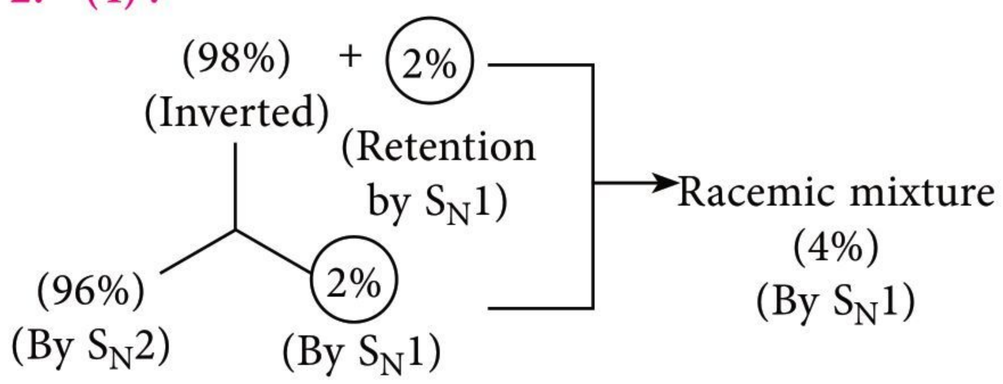
$K.E. \propto T$

$$\frac{(K.E.)_{Ne}}{(K.E.)_{He}} = \frac{727+273}{-73+273} = \frac{1000}{200} = 5 \quad ...(iii)$$

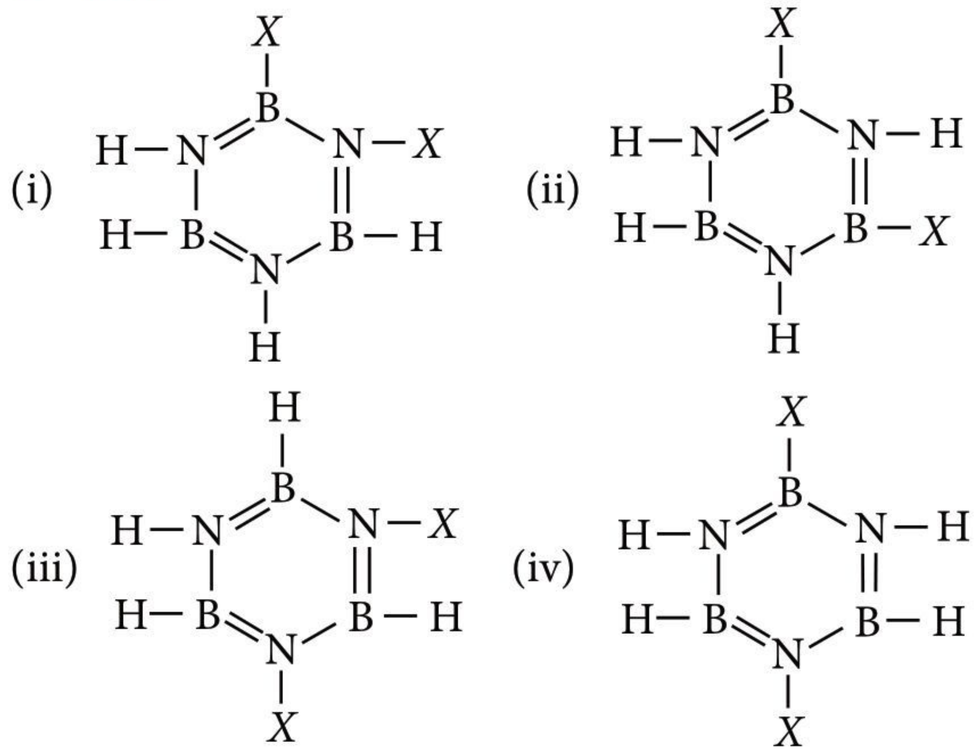
Now, from eqns. (i), (ii) and (iii), we get

$$\frac{\lambda_{He}}{\lambda_{Ne}} = 5$$

2. (4) :

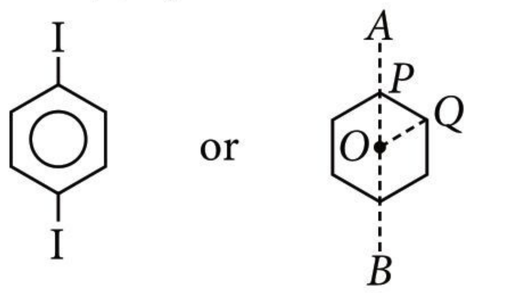


3. (4) :



4. (8) : NO, NO_2, O_2, $K_3[Fe(CN)_6]$, KO_2, $MnSO_4$, $NiSO_4$, $CuSO_4$ are paramagnetic and their apparent weights increase by applying magnetic field.

5. (7) : *p*-Diiodobenzene :



$\therefore$ $AB = OA + OB = 2OA$

$= 2(OP + PA)$
$= 2 \times (PQ + PA)$ ($\because$ $OP = PQ$; ΔOPQ is equilateral)
$= 2$ (PQ + covalent radius of C + covalent radius of I)
$= 2 \times (1.40 + 0.77 + 1.33) = 7.0$ Å

6. (5) : Let x mol of O_2 is liberated and $3x$ mol of $H_2S_2O_8$ is formed.
Reaction at cathode (reduction) :
$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$
Reactions at anode (oxidation) :

(i) $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$ $\left[\begin{array}{l} 1 \text{ mol } O_2 \equiv 4F \\ x \text{ mol } O_2 = 4x \text{ F} \end{array}\right]$

(ii) $2SO_4^{2-} \rightarrow S_2O_8^{2-} + 2e^-$ $\left[\begin{array}{l} 1 \text{ mol } S_2O_8^{2-} \equiv 2F \\ 3x \text{ mol } S_2O_8^{2-} = 6x \text{ F} \end{array}\right]$

Total Faradays at anode = $(4x + 6x)$ F = $10x$ F.
Total Faradays at cathode = $2F \equiv 1$ mol H_2
$10x$ F $\equiv$ Total Faradays at cathode
= Total Faradays at anode
2F at cathode $\equiv$ 1 mol of H_2.

$$\therefore \quad 10x \text{ F at cathode} \equiv \frac{1}{2F} \times 10x \text{ F} = 5x \text{ mol of } H_2.$$

$$\text{Ratio} = \frac{\text{Moles of } H_2 \text{ at cathode}}{\text{Moles of } H_2S_2O_8 \text{ at anode}} = \frac{5x}{3x} = \frac{5}{3}$$

Thus, $a : b$ is 5 : 3.

Thus, $3 \times \frac{a}{b} = 3 \times \frac{5}{3} = 5$

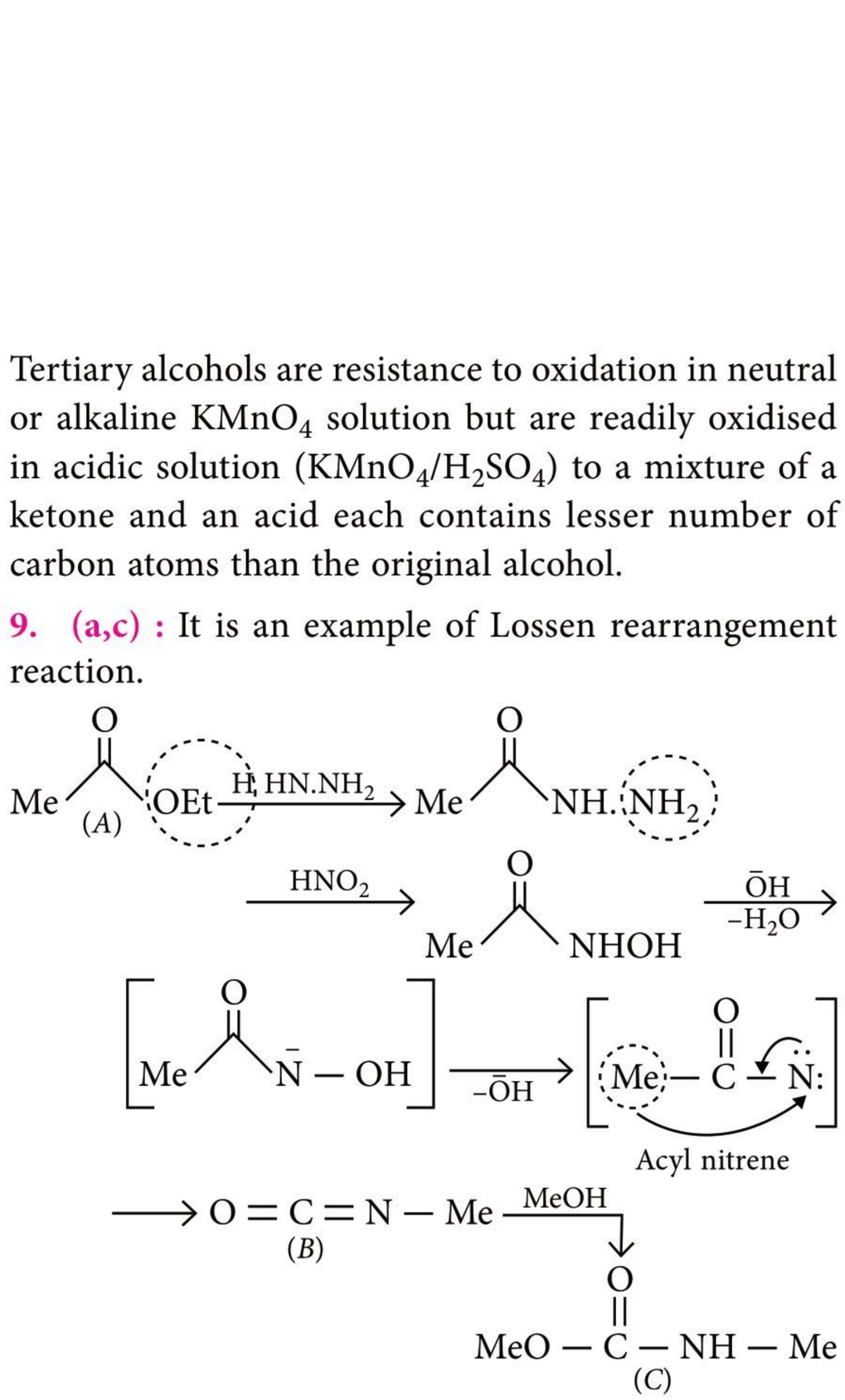
7. (b) : For a constant volume process under adiabatic conditions,
$\Delta U = \Delta U_{\text{heating}} + \Delta U_{298\ \text{K}} = 0$
Hence, $\Delta U_{\text{heating}} = -\Delta U_{298\ \text{K}}$

$$= -\int_{298\ \text{K}}^{T_f} \Sigma n C_v dT = -240.6 \text{ kJ} \qquad \ldots(i)$$

Since, 2 moles unreacted N_2 are associated with 1/2 mole of O_2 ($\because$ Ratio of $N_2 : O_2$ in air = 4 : 1), we have
$\Sigma n C_v = C_v(H_2O, g) + 2C_v(N_2, g)$
$= (39.1 + 2 \times 26.4)$ J $K^{-1} = 91.9$ J K^{-1}
Hence, from eqn. (i), on integrating, we have
91.9 J K^{-1} $(T_f - 298) = 240, 600$ J
$T_f - 298 = 240, 600$ J/91.9 J $K^{-1} = 2618$ K
$T_f = (2618 + 298)$ K = 2916 K

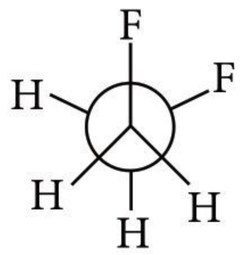
8. (b, c, d) : In acidic medium, $KMnO_4$ gives 5 oxygen while acidic $K_2Cr_2O_7$ gives 3 oxygen and secondary alcohols are oxidised to ketones.
Tertiary alcohols are resistance to oxidation in neutral or alkaline $KMnO_4$ solution but are readily oxidised in acidic solution ($KMnO_4/H_2SO_4$) to a mixture of a ketone and an acid each contains lesser number of carbon atoms than the original alcohol.

9. (a,c) : It is an example of Lossen rearrangement reaction.



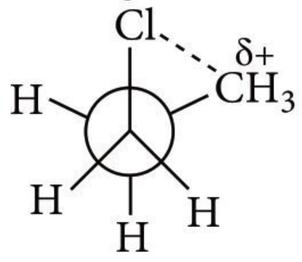
10. (a,b,c) : Due to the presence of double bond character in *p*-nitrochlorobenzene and high bond dissociation enthalpy, it does not show coupling reaction like all three.

11. (a,b,c,d) : $CH_2(F) - CH_2(F)$



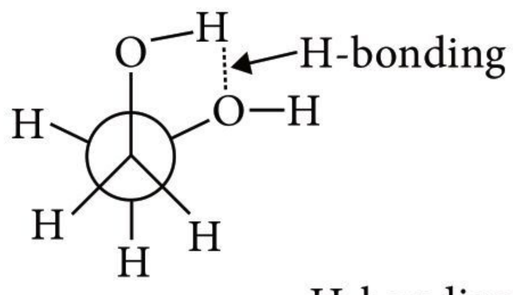
Delocalisation of bond-pair e^- of C–H bond in parallel ABMO of C–F is possible; leads to stability in gauche form

(b) $Cl - CH_2 - CH_2 - CH_3$

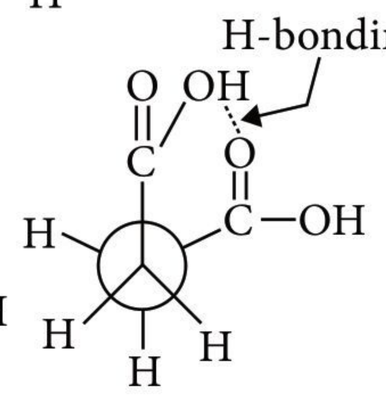


Due to $+I$ nature of $-CH_3$, δ+ created on it while $-I$ nature of –Cl induce δ– on it. Thus, dipole-dipole interaction leads to stability of gauche conformation.

(c) $CH_2(OH) - CH_2(OH)$



(d) $HOOC - CH_2 - CH_2 - COOH$



12. (a, b, c) : Since vessel is thermally insulated, *i.e.*, the process is adiabatic hence, $q = 0$.

Also, $P_{ext} = 0$, hence $w = 0$

From 1st law of thermodynamics, $\Delta E = q + w$

$\therefore \quad \Delta E = 0$

$\therefore \quad \Delta T = 0 \quad$ or $\quad T_2 = T_1$

[$\because$ Internal energy of an ideal gas is a function of temperature.]

Applying ideal gas equation, $PV = nRT$

where n, R and T are constant.

then $P_1V_1 = P_2V_2$

Equation, PV^{γ} = constant, is applicable only for ideal gas in reversible adiabatic process.

Hence, $P_2V_2^{\gamma} = P_1V_1^{\gamma}$ equation is not applicable.

13. (20.5) : Given, $\dfrac{k_{293\,K}}{k_{276\,K}} = 3$; $T_2 = 293$ K and $T_1 = 276$ K

$$2.303\log_{10}\frac{k_2}{k_1} = \frac{E_a}{R}\left(\frac{T_2 - T_1}{T_1T_2}\right)$$

$$\therefore \quad 2.303\log_{10}3 = \frac{E_a}{2}\left(\frac{293-276}{293\times276}\right)$$

$\therefore \quad E_a = 10453.95$ cal $= 10.454$ kcal

Also, $2.303\log_{10}\dfrac{k_3}{k_2} = \dfrac{E_a}{R}\left(\dfrac{T_3 - T_2}{T_3T_2}\right)$

This time, $E_a = 10.454$ kcal; $T_3 = 313$ K and $T_2 = 293$ K

$$\therefore \quad 2.303\log_{10}\frac{k_3}{k_2} = \frac{10.454\times10^3}{2}\left(\frac{313-293}{313\times293}\right)$$

$$\therefore \quad \frac{k_3}{k_2} = 3.12$$

Now, $\dfrac{k_3}{k_2} = \dfrac{t_2}{t_3} \quad \because k \propto \dfrac{1}{\text{time}}$

Also if milk is not soured upto 64 hr at 20 °C, it will not sour upto 192 hr at 3 °C. Similarly, we can have

$$t_3 = t_2 \times \frac{k_2}{k_3} = 64 \times \frac{1}{3.12} = 20.5 \text{ hr}$$

14. (16.6) : $[Ag(H_2O)_2]^+_{(aq)} + NH_{3(aq)} \rightleftharpoons [Ag(NH_3)(H_2O)]^+_{(aq)} + H_2O_{(l)}$ ...(1)

$K_1 = 2.0 \times 10^3$

$$K_1 = \frac{[Ag(NH_3)(H_2O)]^+_{(aq)}}{[Ag(H_2O)_2]^+_{(aq)}[NH_{3(aq)}]} \quad \text{...(i)}$$

$[Ag(NH_3)(H_2O)]^+_{(aq)} + NH_{3(aq)} \rightleftharpoons [Ag(NH_3)_2)]^+_{(aq)} + H_2O_{(l)}$ ...(2)

$K_2 = 8.3 \times 10^3$

$$K_2 = \frac{[Ag(NH_3)_2]^+_{(aq)}}{[Ag(NH_3)(H_2O)]^+_{(aq)}\,[NH_{3(aq)}]} \quad \text{...(ii)}$$

$[Ag(H_2O)_2]^+_{(aq)} + 2NH_{3(aq)} \rightleftharpoons [Ag(NH_3)_2]^+_{(aq)} + 2H_2O_{(l)}$ ...(3)

$$K = \frac{[Ag(NH_3)_2]^+_{(aq)}}{[Ag(H_2O)_2]^+_{(aq)}[NH_{3(aq)}]^2} \quad \text{...(iii)}$$

From equations (i), (ii) and (iii), it is clear that

$K = K_1K_2 = 2 \times 10^3 \times 8.3 \times 10^3 = 16.6 \times 10^6$

15. (158.3) : 0.4 g of $Cu^{2+} = \dfrac{0.4}{31.75} = 0.0126$ g equivalent

At the same time, the oxygen deposited at anode

$= 0.0126$ g equivalent $= \dfrac{8}{32} \times 0.0126 = 0.00315$ g mol

After the complete deposition of copper, the electrolysis will discharge hydrogen at cathode and oxygen at anode.

The amount of charge passed = $1.2 \times 7 \times 60$
$= 504$ coulomb

So, oxygen liberated = $\frac{1}{96500} \times 504 = 0.00523$ g equivalent

$= \frac{8}{32} \times 0.00523 = 0.001307$ g mol

Hydrogen liberated = 0.00523 g equivalent

$= \frac{1}{2} \times 0.00523 = 0.00261$ g mol

Total gases evolved = (0.00315 + 0.001307 + 0.00261) g mol
= 0.007067 g mol
Volume of gases evolved at NTP
= 22400 × 0.007067 mL = 158.3 mL

16. (5.29) : $\Delta T_f = K_f \times i \times m$

$$= K_f \times (1 + \alpha) \times \frac{w_2}{m_1} \times \frac{1000}{w_1(\text{in g})}$$

$$\therefore \quad 0.406 = 1.86 \times (1 + \alpha) \times \frac{0.7}{58.5} \times \frac{1000}{99.3}$$

$$\therefore \quad 1 + \alpha = \frac{0.406 \times 58.5 \times 99.3}{1.86 \times 0.7 \times 1000}$$

Assuming dilute solution,
100 g H_2O = 100 mL H_2O = 0.1 L solutions

$$\pi = i \times \frac{n_2}{V} \times RT = (1+\alpha) \times \frac{w_2}{m_2} \times \frac{1}{V} \times RT$$

$$= \frac{0.406 \times 58.5 \times 99.3}{1000 \times 1.86 \times 0.7} \times \frac{0.7}{58.5} \times \frac{1}{0.1} \times 0.082 \times 298 = 5.29 \text{atm}$$

17. (4.9) : By Gibbs-Helmholtz equation,

$$\Delta G^\circ = \Delta H^\circ + T\left[\frac{d(\Delta G^\circ)}{dT}\right]_p$$

$$\frac{\Delta G^\circ - \Delta H^\circ}{T} = \left[\frac{d(\Delta G^\circ)}{dT}\right]_p$$

But $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$

$$\therefore \quad -\Delta S^\circ = \left[\frac{d\Delta G^\circ}{dT}\right]_p$$

But $\Delta G^\circ = -nFE^\circ_{\text{cell}}$

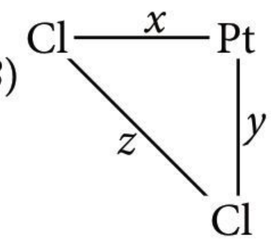
$$\therefore \quad -\Delta S^\circ = -nF\left(\frac{dE^\circ_{\text{cell}}}{dT}\right)_p$$

$\left(\frac{dE^\circ_{\text{cell}}}{dT}\right)_p$ represents variation of e.m.f. of a cell with temperature. It is called temperature coefficient of e.m.f. of a cell.

$$\therefore \quad \left(\frac{dE^\circ_{\text{cell}}}{dT}\right)_p = \frac{\Delta S^\circ}{nF} = \frac{94.6 \text{ J K}^{-1}\text{mol}^{-1}}{2 \times 96500 \text{ C mol}^{-1}}$$

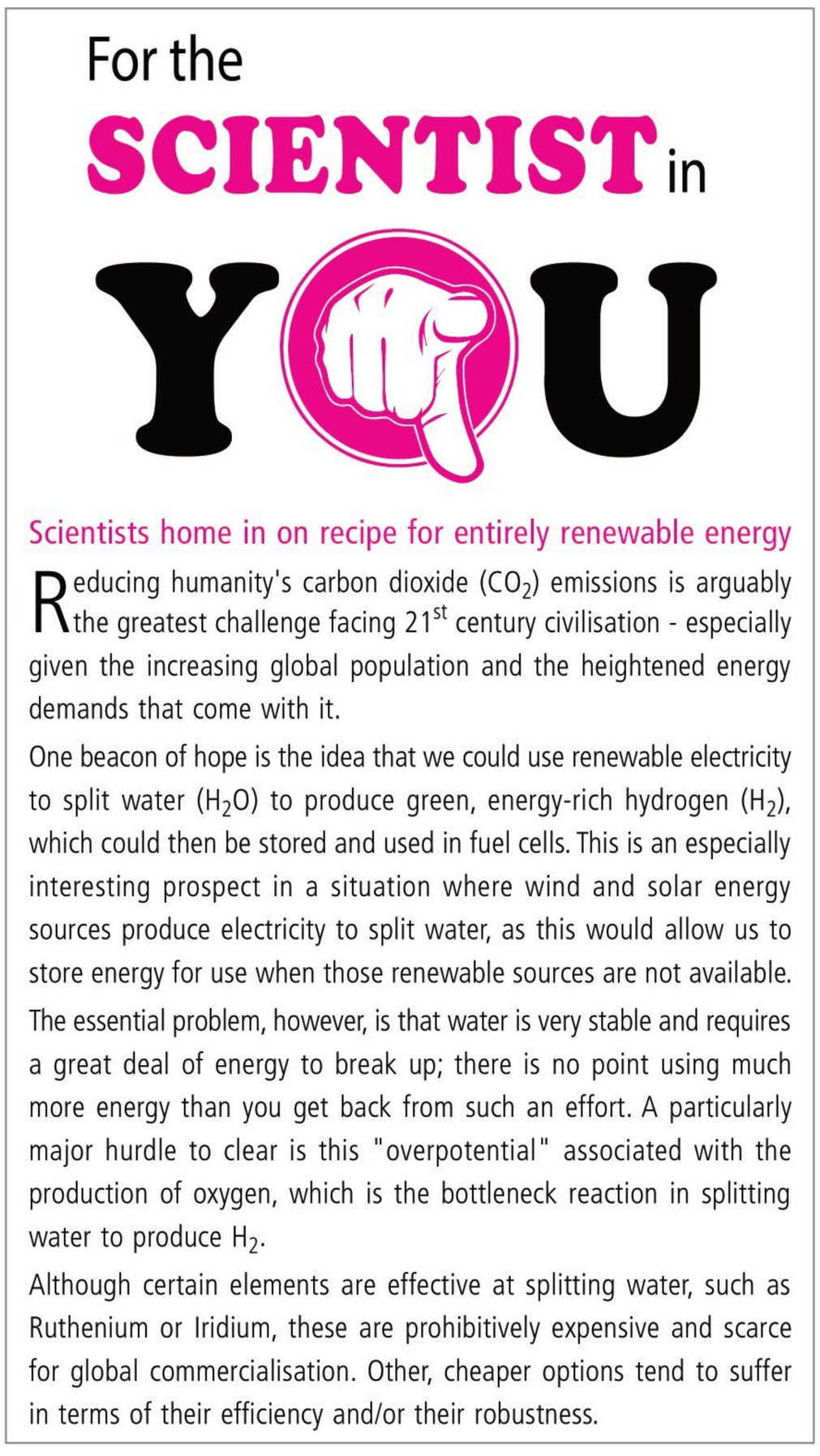
$$\therefore \quad \left(\frac{dE^\circ_{\text{cell}}}{dT}\right)_p = 4.9 \times 10^{-4} \text{ V K}^{-1}$$

18. (3.28) : In compound (*B*)



$$\therefore \quad z^2 = x^2 + y^2 = 2x^2$$

$$z = x\sqrt{2} = 2.32 \times 1.414 = 3.28 \text{ Å}$$



Scientists home in on recipe for entirely renewable energy

Reducing humanity's carbon dioxide (CO_2) emissions is arguably the greatest challenge facing 21st century civilisation - especially given the increasing global population and the heightened energy demands that come with it.

One beacon of hope is the idea that we could use renewable electricity to split water (H_2O) to produce green, energy-rich hydrogen (H_2), which could then be stored and used in fuel cells. This is an especially interesting prospect in a situation where wind and solar energy sources produce electricity to split water, as this would allow us to store energy for use when those renewable sources are not available.

The essential problem, however, is that water is very stable and requires a great deal of energy to break up; there is no point using much more energy than you get back from such an effort. A particularly major hurdle to clear is this "overpotential" associated with the production of oxygen, which is the bottleneck reaction in splitting water to produce H_2.

Although certain elements are effective at splitting water, such as Ruthenium or Iridium, these are prohibitively expensive and scarce for global commercialisation. Other, cheaper options tend to suffer in terms of their efficiency and/or their robustness.

BRUSH UP

for

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CLASS-XI

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Unit 2

Classification of Elements and Periodicity in Properties | Chemical Bonding and Molecular Structure

Classification of Elements and Periodicity in Properties

History of the Periodic Table

Earlier Attempts

Dobereiner's Triads

In the triad of elements, the atomic weight of middle element is the arithmetic mean of other two.

Newland's Law of Octaves

Elements are arranged in increasing order of their atomic weights, the properties of every eighth element are similar to the first one.

Mendeleev's Periodic Table

Elements are arranged such that the properties of the elements are the periodic function of their atomic weights. Table contains 8 groups and 7 periods.

Modern Periodic Table

Modern Periodic Law

- The physical and chemical properties of elements are periodic function of their atomic numbers.
- Elements are arranged in order of increasing atomic numbers.
- It has seven horizontal rows known as periods and eighteen vertical columns known as groups.

Elements in Periodic Table

***s*-block elements**

- Group-1 to 2
- *E.C.* : ns^{1-2}
- Group-1 elements form M^{+}ions.
- Group-2 elements form M^{2+} ions.

***p*-block elements**

- Group -13 to 18
- *E.C.* : $ns^2\ np^{1-6}$ (excluding helium)
- Except noble gases and fluorine, all other elements show variable oxidation states.

***d*-block elements**

- Group - 3 to 12
- Lies between *s*- and *p*-block elements
- *E.C.* : $(n-1)d^{1-10}ns^{0-2}$
- Show variable valencies and oxidation states.

***f*-block elements**

- 4*f*-series : lanthanides
- 5*f*-series : actinides
- *E.C.* : $(n-2)\ f^{1\text{-}14}\ (n-1)d^{0-1}ns^2$
- Variable oxidation states, most common is +3.

Periodic Trends

Atomic Radius

- **Crystal or metallic radius :** It is one-half of the internuclear distance between the two nearest atoms in the metallic lattice. It is generally used for metals.
- **van der Waals' radius :** It is one-half of the internuclear distance between the two adjacent identical atoms belonging to two neighbouring molecules of an element.
- **Covalent radius :** It is one-half of the distance between the centres of the nuclei of two similar atoms joined by a single covalent bond. This is generally used for non-metals.
  - The atomic radii of noble gases or inert gases are, in fact, van der Waals' radii since they do not form molecules.
  - van der Waals' radius > metallic radius > covalent radius (for an atom)

Ionic Radius

- It is the distance between the nucleus and the point where the nucleus exerts its influence on the electron cloud.
  - Cation is smaller and anion is larger than the parent atom of the element. In case of isoelectronic ions, the size decreases with increase in the nuclear charge.

Ionisation Enthalpy

- It is the energy required to remove an electron from an isolated gaseous atom in its ground state.
  $M_{(g)} + I.E. \rightarrow M^{+}_{(g)} + e^{-}$
- $I.E. \propto \frac{1}{\text{size of atom}} \propto$ Effective nuclear charge $\propto \frac{1}{\text{Screening effect}}$
- Completely or half-filled orbital has higher *I.E.* because of higher stability.

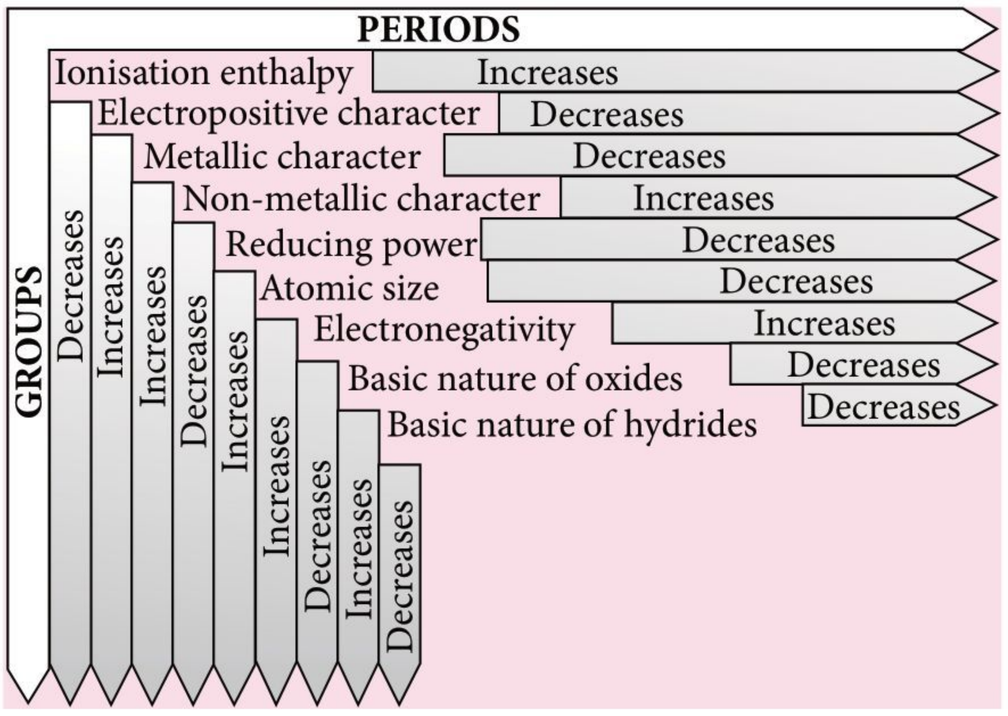
Electron Gain Enthalpy

- It is the amount of energy released when an electron is added to an isolated gaseous atom.
  $A_{(g)} + e^{-} \rightarrow A^{-}_{(g)}\ ;\ \Delta_{eg}H$
- $\Delta_{eg}H \propto \frac{1}{\text{Size of atom}} \propto$ Effective nuclear charge $\propto \frac{1}{\text{Screening effect}}$

Electronegativity

- It is the tendency of an atom to attract the shared pair of electrons towards itself in a covalent bond.
- Mulliken scale of electronegativity
  $\chi = \frac{1}{2}\ [\Delta_i H + \Delta_{eg} H]$
- Pauling scale of electronegativity
  $\chi_A - \chi_B = 0.1017\sqrt{\Delta}$
  where, $\Delta = E_{A-B} - \frac{1}{2}\sqrt{E_{A-A} + E_{B-B}}$
  Here, E represents bond dissociation enthalpy (in kJ mol^{-1}).
- Percentage of ionic character
  $= 16(\chi_A - \chi_B) + 3.5(\chi_A - \chi_B)^2$
  - If $\chi_A - \chi_B = 1.7$, bond is 50% covalent and 50% ionic.
  - If $\chi_A - \chi_B > 1.7$, bond is predominately ionic.
  - If $\chi_A \approx \chi_B$, A — B bond is purely covalent.

Summary of some general trends



Chemical Bonding and Molecular Structure

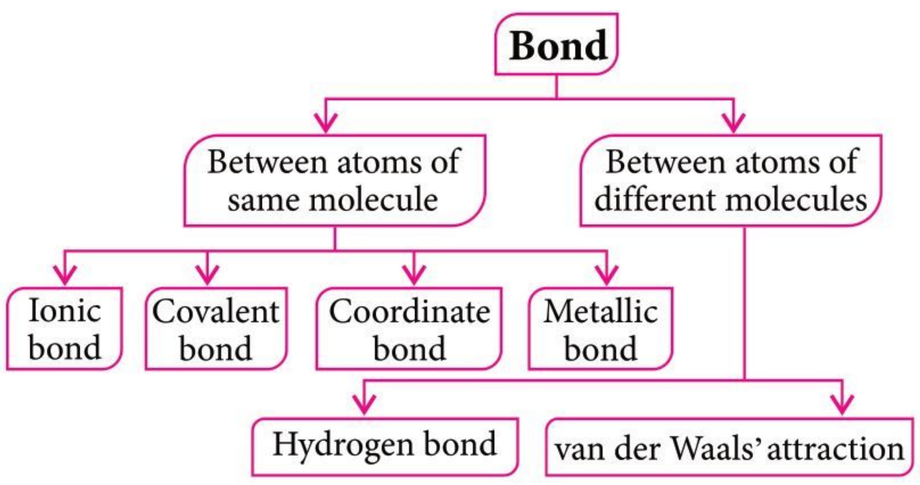
The phenomenon of union of two or more atoms involving redistribution of electrons, so that each atom involved in bonding acquires stable configuration in order to gain stability is known as chemical bonding.

- Atoms form bonds since it leads to decrease in energy.
- Whenever atoms come close, both attractive and repulsive forces operate and if the magnitude of attractive forces is more than those of repulsive forces, a chemical bond is formed.

Kössel-Lewis Approach to Chemical Bonding

Atoms can combine either by transfer of valence electrons from one atom to another or by sharing of valence electrons in order to have an octet in their valence shell (octet rule).

Types of Bond



Bond Formation

- Nature of bond formed between two atoms depends upon electropositive and electronegative character of bonded atoms.
  - **Ionic bond :** Electropositive element + Electronegative element
  - **Covalent bond :** Electronegative element + Electronegative element
  - **Metallic bond :** Electropositive element + Electropositive element

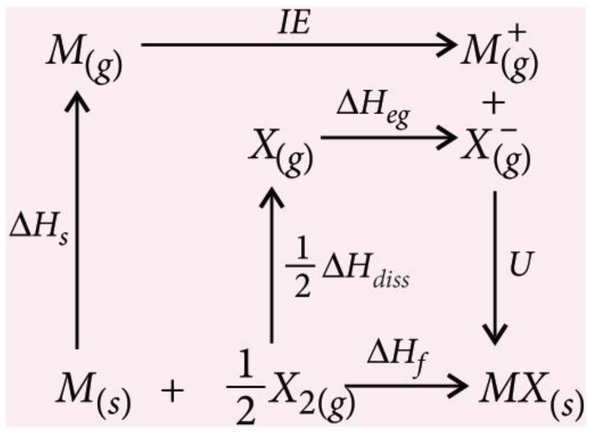
  Ionic bond is non-directional in nature while covalent bonds are directional in nature.

Ionic Bond

- The bonds formed between atoms by transferring of valence electrons from one atom to another is said to be electrovalent or ionic bond, and the compound so formed is an ionic compound.
- **Conditions for the formation of electrovalent bond :**
  - **Number of valence electrons :** The atom which changes to a cation must contain 1, 2 or 3 valence electrons and the one changing to anion must contain 5, 6 or 7 valence electrons.
  - **Electronegativity difference :** Higher the electronegativity difference between the atoms, more ionic will be the bond formed.
  - **Low ionisation energy :** Ionisation energy of the element forming the cation *i.e.,* metal, should be low.
  - **High electron affinity :** Electron affinity of the element forming anion *i.e.,* non-metal, should be high.
  - **High lattice energy :** Higher the lattice energy, greater is the ease of formation of ionic compound.

Born Haber Cycle

- Born Haber cycle is based on Hess's law of constant heat summation and it correlates the energy changes taking place in various steps involved in the formation of ionic compounds.
- The steps can be represented in the cycle as :



$$\Delta H_f = \Delta H_s + IE + \frac{1}{2}\Delta H_{diss} + \Delta H_{eg} + U$$

where, ΔH_f = Enthalpy of formation,
ΔH_s = Enthalpy of sublimation,
IE = Ionisation energy,
ΔH_{diss} = Enthalpy of dissociation,
ΔH_{eg} = Electron gain enthalpy
and U = Lattice energy.

Covalent Bond

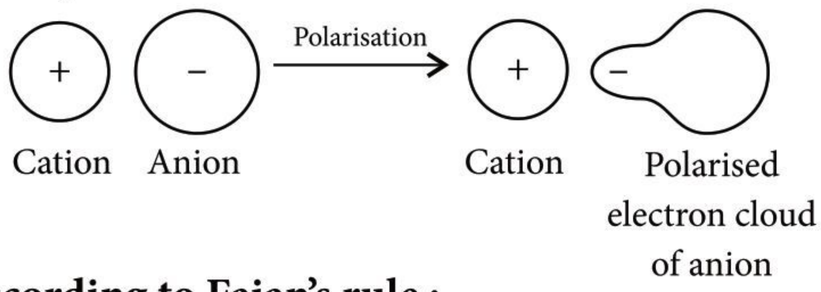
- Bond formed by sharing of electrons between the combining atoms is called covalent bond and the compound so formed is a covalent compound.

Coordinate Bond

- A covalent bond in which both electrons of the shared pair are contributed by one of the atoms only, is called a coordinate bond or dative bond and the compound is called a coordinate compound.

Polarisation

- **Fajan's rule :** In ionic bond, some covalent character is introduced because of the tendency of the cation to polarise the anion. In fact, cation attracts the electron cloud of the anion and pulls electron density between two nuclei.



- **According to Fajan's rule :**
  - Smaller the size of cation, larger is its polarising power.
  - Larger the size of anion, more will be its polarisability.
  - More the charge on cation and anion, more is the covalent character.
  - Cations having 18 electrons in outermost shell bring greater polarisation than the other which have 8 electrons in outermost shell.

Important Terms and Formulae

- Formal charge of an atom in a Lewis structure = Total no. of electrons in the free atom – Total no. of electrons of lone pairs (non-bonding electrons) $-1/2 \times$ Total no. of shared electrons (bonding electrons)

  i.e., $F = V - L - \frac{1}{2}S$

- **Bond length :** Equilibrium distance between the nuclei of two bonded atoms in a molecule.
  - Bond length $\propto$ size of atoms, $\propto \frac{1}{\text{bond order}}$
- **Bond angle :** Angle between the orbitals containing bonding electron pairs around the central atom in a molecule/complex ion.
- **Bond enthalpy :** Amount of energy required to break one mole of bonds between two atoms in a gaseous state.
- **Bond order :** Number of bonds formed between two atoms in a covalent compound.
- **Resonance :** The phenomenon of existence of a molecule in different structural forms, each of which can explain most of the properties of the molecule but none can explain all the properties of the molecule.
- Dipole moment (μ) = Charge $\times$ Distance of separation

Theories of Covalent Bonding

VSEPR Theory (Nyholm and Gillespie)

- The shape of a molecule depends upon the number of valence shell electron pairs (bonded or non bonded) surrounding the central atom.
- Electron pairs tend to occupy such positions in space which minimise repulsions.
- The repulsive interactions of electron pairs decreases in the order : $lp - lp > lp - bp > bp - bp$

Valence Bond Theory (Pauling)

- A bond is formed between two atoms when the forces of attraction are greater than forces of repulsion.
- A covalent bond is formed between two atoms by pairing of electrons present in the valence shell having opposite spins.
- During bond formation, only valence electrons loose their identity.
- Bond formation is accompanied by release of energy and this accounts for the stability of bond.
- Sigma (σ) bond is formed by the head on overlap of atomic orbitals.
- Pi (π) bond is formed by lateral overlap of half-filled atomic orbitals, perpendicular to internuclear axis.

Molecular Orbital Theory (F. Hund and R.S. Mulliken)

- Molecular orbitals are formed by the linear combination of atomic orbitals.
- The number of molecular orbitals formed is equal to the number of atomic orbitals combined.

- When two atomic orbitals combine they form one bonding molecular orbital of lower energy and one anti-bonding molecular orbital of higher energy.
- The molecular orbitals are filled in accordance with Aufbau principle, Pauli's exclusion principle and Hund's rule.
- Energy order for molecular orbitals upto N_2 is

  $\sigma 1s < \sigma^* 1s < \sigma 2s < \sigma^* 2s < \pi 2p_x = \pi 2p_y < \sigma 2p_z < \pi^* 2p_x = \pi^* 2p_y < \sigma^* 2p_z$
- Energy order for molecules beyond N_2

  $\sigma 1s < \sigma^* 1s < \sigma 2s < \sigma^* 2s < \sigma 2p_z < \pi 2p_x = \pi 2p_y < \pi^* 2p_x = \pi^* 2p_y < \sigma^* 2p_z$
- Bond order (B.O.) $= \frac{1}{2}(N_b - N_a)$

  where, N_b is number of electrons present in BMO and N_a is number of electrons present in ABMO
  - If $N_b > N_a$; B.O. = +ve, the molecule is stable.
  - If $N_b < N_a$; B.O. = –ve, the molecule is unstable or does not exist.
  - If $N_b = N_a$; B.O. = 0, the molecule is unstable or does not exist.
  - Isoelectronic species have same bond order.

HYBRIDISATION

- Hybridisation is a hypothetical phenomenon. It is introduced to explain shapes of molecules and bonding parameters such as bond angle, strength of bonds.
- The structure of a molecule can be predicted on the basis of hybridisation by using the formula :

  $$H = \frac{1}{2}(V + M - C + A)$$

  where, H = number of orbitals involved in hybridisation, V = number of electrons in valence shell of the central atom, M = number of monovalent atom, C = charge on cation and A = charge on anion.

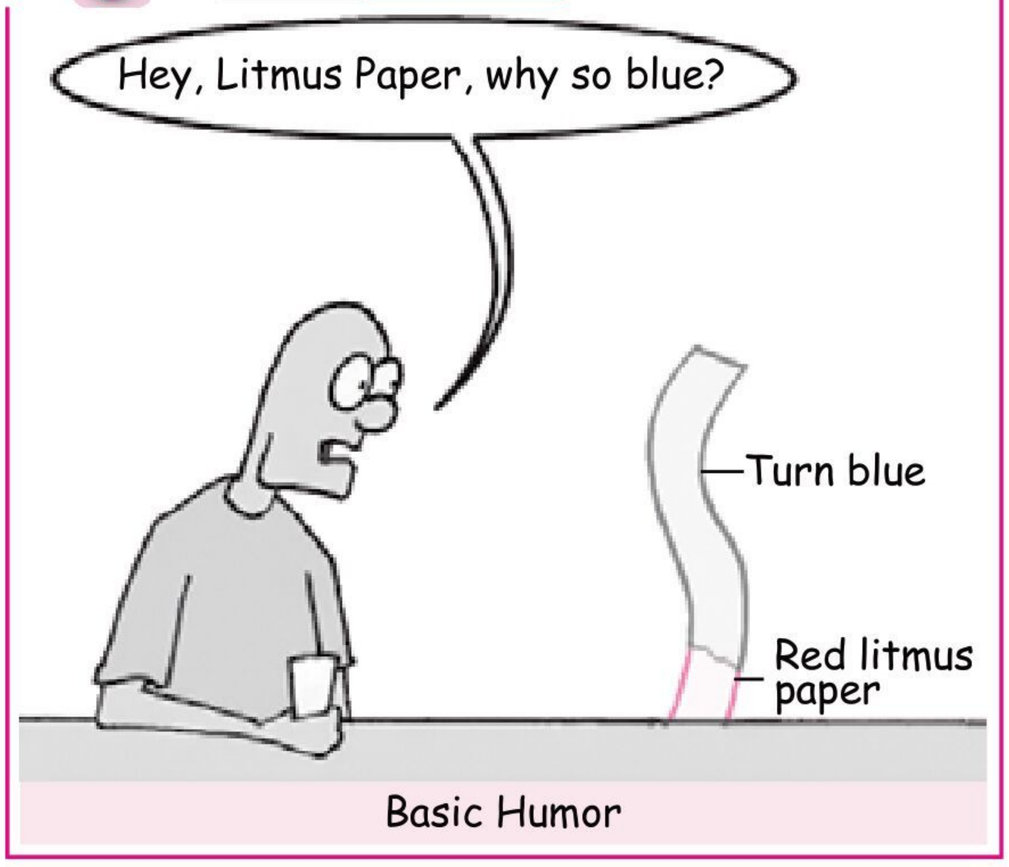
MOLECULES HAVING BOND PAIRS ONLY

Type of hybridisation	No. of hybrid orbitals	Shape of molecule	Bond angle	Examples
sp	2	Linear	180°	$BeCl_2$, BeF_2, CO_2
sp^2	3	Trigonal planar	120°	BF_3, BCl_3
sp^3	4	Tetrahedral	109.5°	CH_4, CCl_4
dsp^2	4	Square planar	90°	$[Ni(CN)_4]^{2-}$ $[PtCl_4]^{2-}$
dsp^3 or sp^3d	5	Trigonal bipyramidal	120° and 90°	PCl_5, PF_5
d^2sp^3 or sp^3d^2	6	Octahedral	90°	SF_6
d^3sp^3 or sp^3d^3	7	Pentagonal bipyramidal	72° and 90°	IF_7

MOLECULES HAVING BOND PAIRS AND LONE PAIRS

Type of molecule	Hybridisation	Bond angle	Actual shape	Examples
AB_2L	sp^2	<120°	V-shape or Bent	SO_2, $PbCl_2$
AB_2L_2	sp^3	<109°28′	V-shape or Bent	H_2O, Cl_2O
AB_2L_3	sp^3d	180°	Linear	XeF_2
AB_3L_2	sp^3d	90°	T-shape	ClF_3
AB_3L_1	sp^3	<109°28′	Trigonal pyramidal	NH_3, PCl_3
AB_4L_1	sp^3d	120°, 90°	See saw or Distorted tetrahedron	SF_4, SCl_4
AB_4L_2	sp^3d^2	90°	Square planar	XeF_4
AB_5L_1	sp^3d^2	<90°	Square pyramidal	IF_5
AB_6L_1	sp^3d^3	–	Distorted octahedral	XeF_6

COMIC CAPSULE



WRAP it up!

MCQs Type

1. In which of the following, the bond angle between two covalent bonds is the maximum?
(a) H_2O (b) NH_3 (c) CO_2 (d) CH_4

2. Five ionization energy values in kJ/mol are listed below: $E_1 = 870$, $E_2 = 830$, $E_3 = 1010$, $E_4 = 1290$, $E_5 = 376$. These are
(a) successive ionization energies for the element with atomic number 5
(b) the first *I.E.* of successive elements in group 15, 16, 17, 18 and 1 respectively
(c) the first *I.E.* of elements with atomic number 1 to 5
(d) successive *I.E.* for transition elements with four electrons in *d*-subshell.

3. Identify the incorrect match.

Name	IUPAC Official Name
(A) Unnilunium	(i) Mendelevium
(B) Unniltrium	(ii) Lawrencium
(C) Unnilhexium	(iii) Seaborgium
(D) Unununnium	(iv) Darmstadtium

(a) (A), (i) (b) (B), (ii)
(c) (C), (iii) (d) (D), (iv) **(NEET 2020)**

4. The electronic configuration of an element is $1s^2, 2s^2, 2p^6, 3s^2, 3p^3$. What is the atomic number of the element which is just below the given element in the periodic table?
(a) 34 (b) 49 (c) 33 (d) 31

5. The bond angles in molecules H_2O, NH_3, CH_4 and CO_2 are in the order.
(a) $H_2O > HN_3 > CH_4 > CO_2$
(b) $H_2O > NH_3 < CO_2 > CH_4$
(c) $H_2O < NH_3 < CH_4 < CO_2$
(d) $H_2O > NH_3 < CH_4 < CO_2$

6. In general, the properties that decrease and increase down a group in the periodic table, respectively are
(a) atomic radius and electronegativity
(b) electronegativity and electron gain enthalpy
(c) electronegativity and atomic radius
(d) electron gain enthalpy and electronegativity.
(JEE Main 2019)

7. Which of the following statements is wrong?
(a) In *s*-block elements, the 1^{st} ionization energy decreases down the group.
(b) In *p*-block elements, the decrease in 1^{st} ionization energy is large between 1^{st} and 2^{nd} element but thereafter the decrease is minor.
(c) In transition elements, the ionization energy decreases regularly down the group from 5^{th} group.
(d) In a transition series, the 2^{nd} *IP* value is more for Cr and Cu groups compared to the adjacent groups.

8. Which of the following has highest bond angle?
(a) NO_2^+ (b) NO_2
(c) NO_2 (d) NO_3

9. In a periodic table, the basic character of oxides
(a) increases from left to right and decreases from top to bottom
(b) decreases from right to left and increases from top to bottom
(c) decreases from left to right and increases from top to bottom
(d) decreases from left to right and increases from bottom to top.

10. Which of following is the correct order of ionisation enthalpy?
(a) $Te^{2-} < I^- < Cs^+ < Ba^{2+}$
(b) $I^- < Te^{2-} < Cs^+ < Ba^{2+}$
(c) $Te^{2-} < Cs^+ < I^- < Ba^{2+}$
(d) $Ba^{2+} < Cs^+ < I^- < Te^{2-}$

MONTHLY TEST DRIVE CLASS XI ANSWER KEY

1.	(c)	2.	(b)	3.	(c)	4.	(a)	5.	(b)
6.	(a)	7.	(c)	8.	(c)	9.	(d)	10.	(d)
11.	(b)	12.	(d)	13.	(a)	14.	(d)	15.	(b)
16.	(c)	17.	(b)	18.	(a)	19.	(a)	20.	(b, d)
21.	(a,d)	22.	(a,b,d)	23.	(a,b,c,d)	24.	(4)	25.	(3)
26.	(3)	27.	(c)	28.	(b)	29.	(d)	30.	(b)

11. Which one has minimum dipole moment?
(a) Butene–1
(b) *cis*-Butene–2
(c) *trans*-Butene–2
(d) 2-Methyl propene

12. Which of the following grouping represents a collection of isoelectronic species?
(a) N^{3-}, F^-, Na^+ (b) Ca^{2+}, Cs^+, Br^-
(c) Be, Al^{3+}, Cl^- (d) Na^+, Ca^{2+}, Mg^{2+}

13. Atomic number of Ag is 47. In the same group, the atomic numbers of elements placed above and below Ag in long form of periodic table will be
(a) 29, 65 (b) 39, 79
(c) 29, 79 (d) 39, 65

14. In which of the following molecules, the central atom has two lone pairs of electrons?
(a) SF_4 (b) BrF_5 (c) SO_2 (d) XeF_4

15. The correct order of decreasing polarisability of the ions is
(a) Cl^-, Br^-, I^-, F^- (b) F^-, I^-, Br^-, Cl^-
(c) F^-, Cl^-, Br^-, I^- (d) I^-, Br^-, Cl^-, F^-

16. Which of the following diatomic molecular species has only π bonds according to Molecular Orbital Theory?
(a) Be_2 (b) O_2
(c) N_2 (d) C_2 **(NEET 2019)**

17. Which of the following has highest lattice energy?
(a) LiF (b) NaF (c) KF (d) RbF.

18. Generally, the first ionisation energy increases along a period. But there are some exceptions. The one which is not an exception is
(a) Na and Mg (b) Be and B
(c) N and O (d) Mg and Al.

19. In which of the following processes the maximum amount of energy is involved?
(a) $Cl \rightarrow Cl^-$ (b) $Br \rightarrow Br^-$
(c) $F \rightarrow F^-$ (d) $I \rightarrow I^-$

20. Ratio of π to σ bonds in benzene is
(a) 1 : 2 (b) 1 : 6
(c) 1 : 4 (d) 1 : 1.

21. The correct order in which the first ionisation potential increases is
(a) K, Be, Na (b) Be, Na, K
(c) Na, K, Be (d) K, Na, Be.

22. The dipole moments of CCl_4, $CHCl_3$ and CH_4 are in the order
(a) $CH_4 = CCl_4 < CHCl_3$
(b) $CHCl_3 < CH_4 = CCl_4$
(c) $CH_4 < CCl_4 < CHCl_3$
(d) $CCl_4 < CH_4 < CHCl_3$ **(JEE Main 2019)**

23. The pair of species with similar shape is
(a) PCl_3, NH_3 (b) CF_4, SF_4
(c) $PbCl_2$, CO_2 (d) PF_5, IF_5

24. The calculated bond order in O_2^- ions is
(a) 1 (b) $1\frac{1}{2}$
(c) 2 (d) $2\frac{1}{2}$

25. In which of the following compound(s) F atom(s) can occupy any position around central atom?
(a) PCl_4F (b) BrF_3
(c) PCl_5F^- (d) None of these

Numerical Value Type

26. Complexes (ML_5) of metals Ni and Fe have ideal square pyramidal and trigonal bipyramidal geometries, respectively. The sum of the 90°, 120° and 180° *L-M-L* angles in the two complexes is _____.
(JEE Main 2020)

27. The percentage ionic character of a bond having 1.275 Å its length and 1.03 D its dipole moment is

28. Using the following data, calculate the electro-negativity of fluorine.
$E_{H—H} = 104.2$ kcal mol^{-1}, $E_{F—F} = 36.6$ kcal mol^{-1}
$E_{H—F} = 134.6$ kcal mol^{-1}, $\chi_H = 2.1$.

29. The number of species among the following which have fractional bond order is
Li_2, He_2^+, N_2^+, N_2^{2-}, O_2^+, O_2^{2-}, O_2^-, CO_3^{2-}, C_6H_6, O_3

30. In the hypothetical molecule AX_2L_n (where *A* is central atom, *X* is surrounding atom *L* is lone pair, *n* is the number of lone pair), for which possible value of "*n*" will the dipole moment of the molecule be minimum?

SOLUTIONS

1. **(c) :** In CO_2 the bond angle is maximum (180°) because the molecule is linear.

2. **(b) :** *I.E.* values are increasing gradually and suddenly decreased in the E_5 value indicating a change from noble gas to alkali metal.

CONCEPT MAP

SOME BASIC CONCEPTS OF CHEMISTRY

Law of Conservation of Mass

- Proposed by the French Chemist Antoine Lavoisier (1789)
- Mass can neither be created nor destroyed in a chemical reaction.

OR

- For any chemical process in a closed system, the mass of the reactants must be equal to the mass of the products.

e.g., $C + O_2 \rightarrow CO_2$

12 g 32 g 44 g

Oxygen + Hydrogen → Water

32 g 4 g 36 g

Law of Definite Proportions

- Proposed by Louis Proust (1799)
- A chemical compound always consists of the same elements combined together in the same ratio, irrespective of the method of preparation or the source from it is taken.

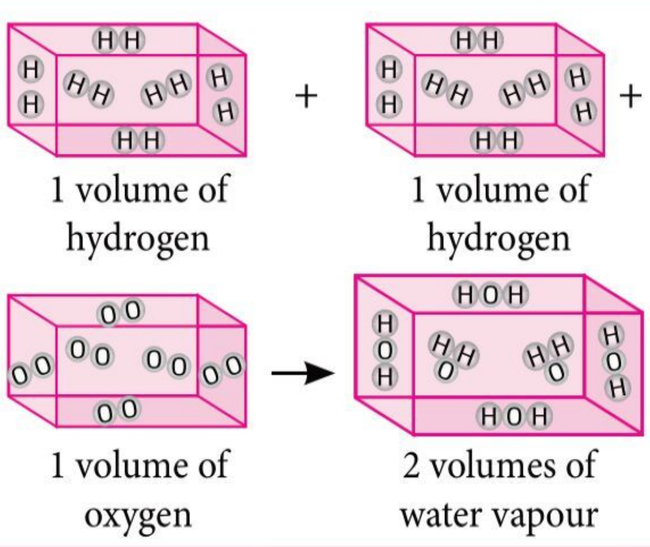
In the formation of water compound, the ratio of the mass of hydrogen to the mass of oxygen is always 1 : 8, whatever be the source of water. Thus, if 9 g of water is decomposed, 1 g of hydrogen and 8 g of oxygen are always obtained.

Law of Multiple Proportions

- Proposed by John Dalton (1804)
- When elements combine, they do so in the ratio of small whole numbers. *e.g.*, carbon and oxygen react to form CO or CO_2, but not $CO_{1.8}$.

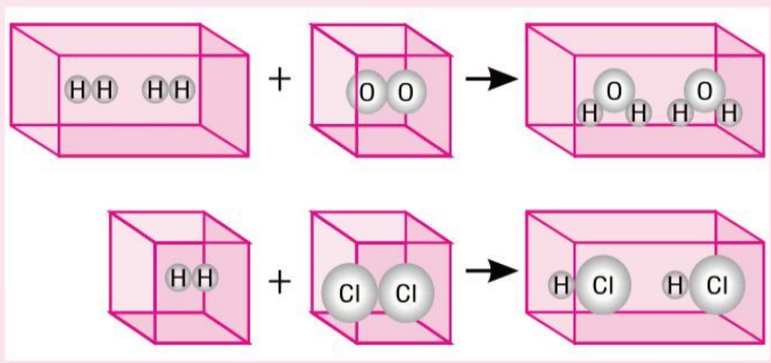
Avogadro's Law

- Proposed by Avogadro (1811)
- Equal volumes of gases at the same temperature and pressure should contain equal number of molecules.



Gay Lussac's Law of Gaseous Volumes

- Proposed by Gay Lussac (1808)
- At a given temperature and pressure, the volumes of all gaseous reactants and products bear a simple whole number ratio to each other.

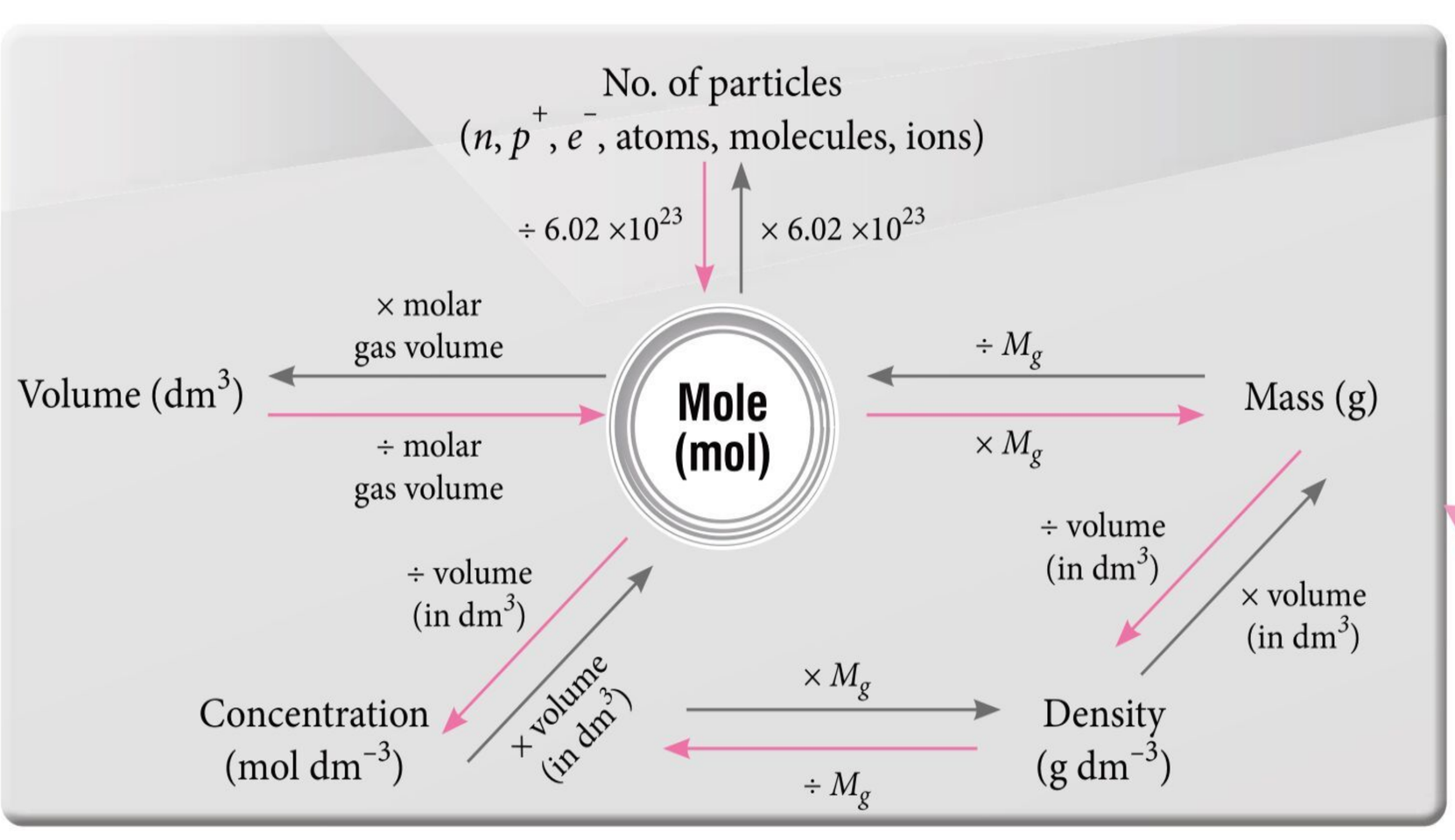


CONCENTR TERM

LAWS OF CHEMICAL COMBINATIONS

SO CO CH

MOLE CONCEP



Concentration Terms

- Mass percent (%) = $\frac{w_{solute}}{w_{solution}} \times 100$
- Normality, $N = \frac{w_B \times 1000}{\text{eq. wt. of solute} \times V \text{ (in mL)}}$

  N = (Basicity or Acidity) $\times M$
- Molarity, $M = \frac{w_B \times 1000}{M_B \times V(\text{in mL})}$
- Relation between molarity and molality

  $\frac{1}{m} = \frac{d}{M} - \frac{M_B}{1000}$
- Molality, $m = \frac{w_B \times 1000}{M_B \times w_A(\text{in g})}$
- Mole fraction, $x_A = \frac{n_A}{n_A + n_B}$, $x_B = \frac{n_B}{n_A + n_B}$
- Relation between molality and mole fraction

  $m = \frac{x_B \times 1000}{(1 - x_B) \times M_A}$

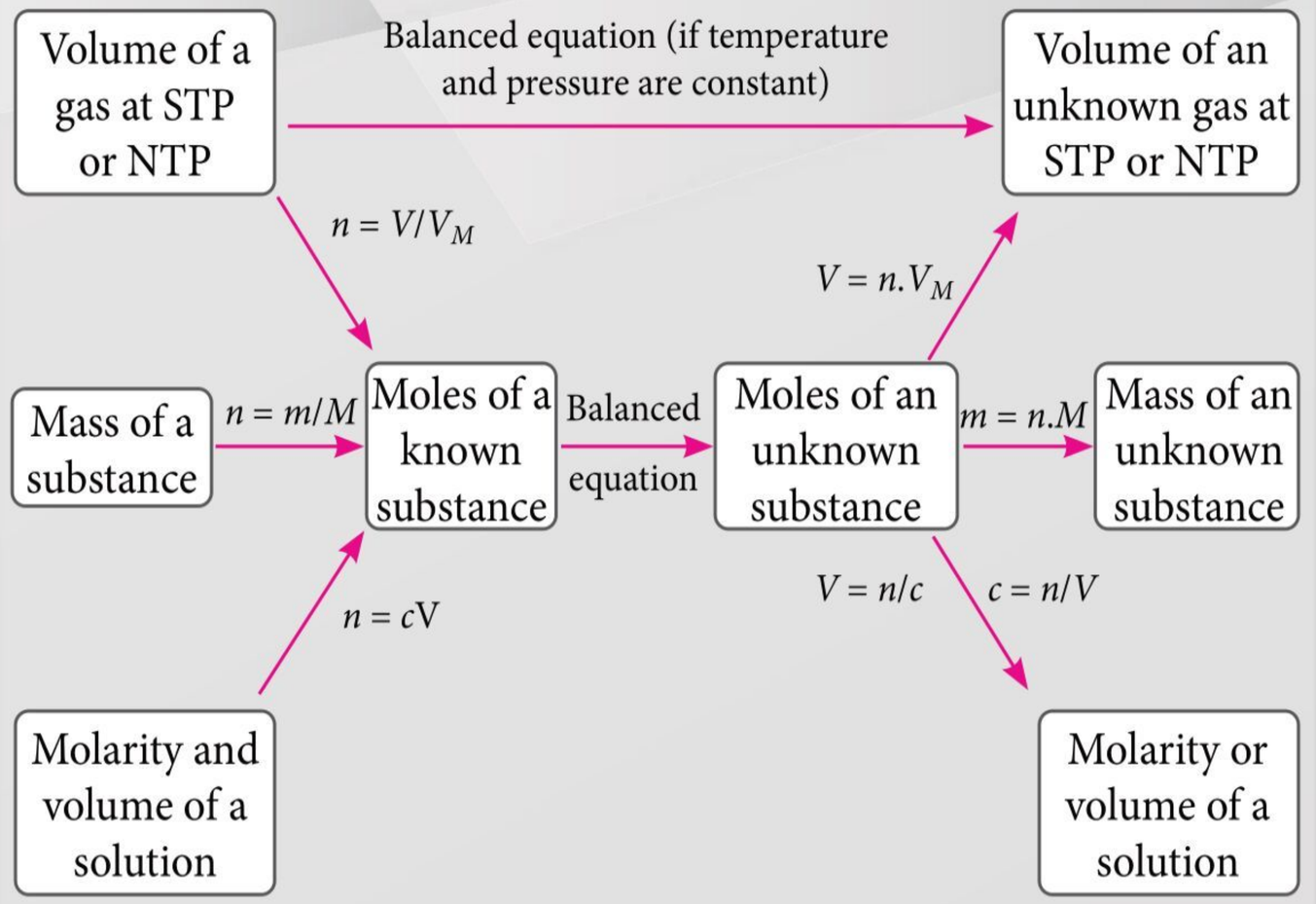
Limiting Reagent

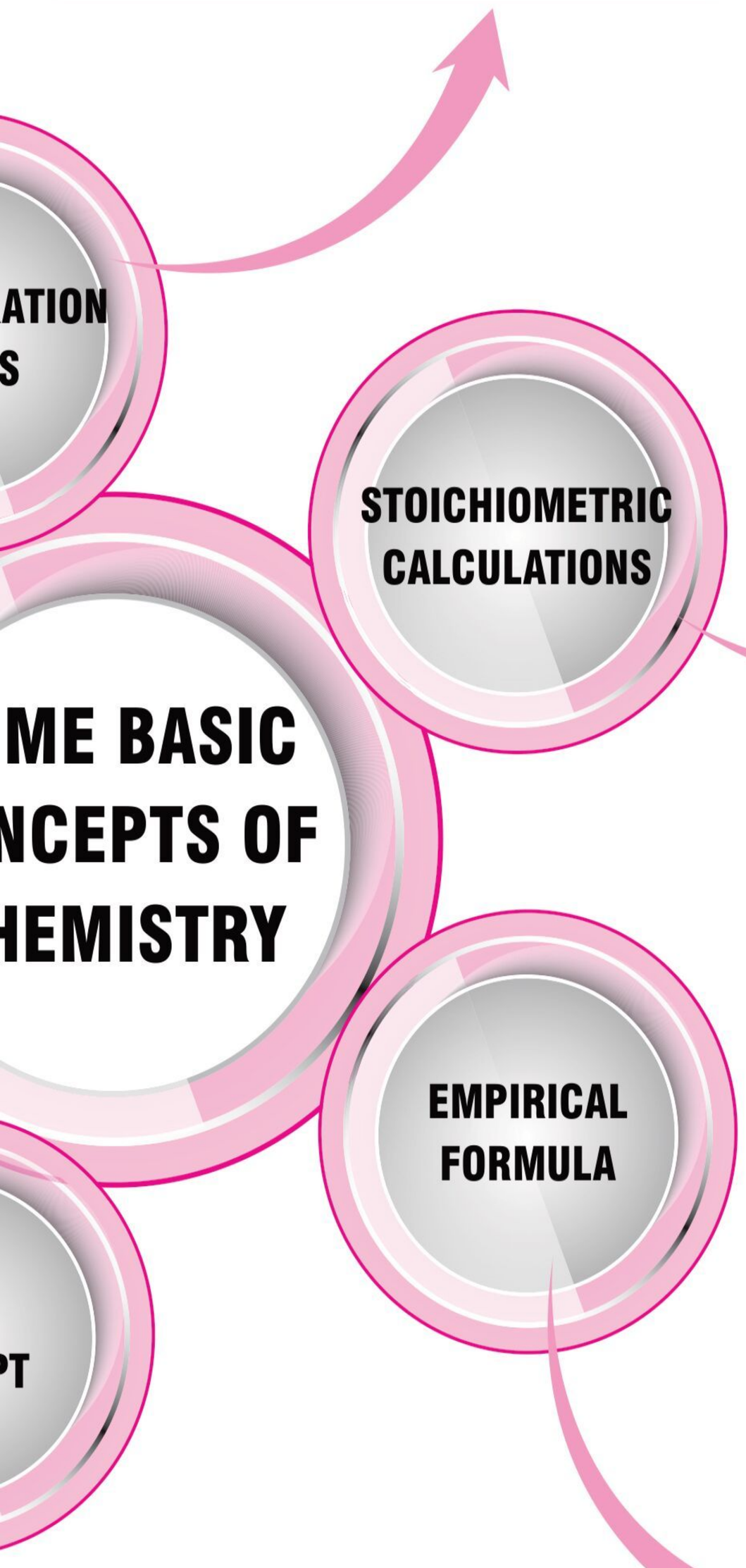
The reactant which present in lesser amount and gets consumed and limits the amount of product formed is called limiting reagent.

e.g., $\underset{2\text{ g}}{H_2} + 1/2O_2 \rightleftharpoons \underset{16\text{ g}}{H_2O}$

For every 16 g of oxygen, 2 g H_2 is required, if H_2 is present less than 2 g then it will be limiting reagent.

Mole Calculations





Empirical Formula

- Mass % elements
- ⇓ Assume 100 g sample
- Calculate the grams of each element
- ⇓ Use atomic weights
- Calculate the moles of each element
- ⇓ Calculate the molar ratio for each element
- Assign empirical formula

Molecular Formula

- Empirical formula
- ⇓
- Empirical formula mass
- ⇓ Use molecular mass
- Calculate n = Molecular mass / Empirical formula mass
- ⇓
- Molecular formula = $n \times$ Empirical formula

3. **(d) :** Unnilunium – Mendelevium ⟹ (a)-(i)
Unniltrium – Lawrencium ⟹ (b)-(ii)
Unnilhexium – Seaborgium ⟹ (c)-(iii)
Unununnium – Roentgenium ⟹ (d)✳(iv)

4. **(c)**

5. **(c) :** Bond angles are H_2O (104.5°), NH_3 (107°), CH_4 (109.5°) and CO_2(180°).

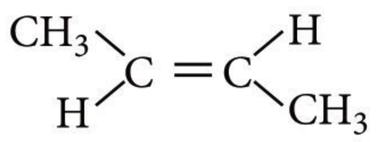
6. **(c)**

7. **(c) :** In a transition group (from 5^{th} group) ionization energy decreases from first to second element but from second to third element the ionization energy does not decrease due to lanthanide contraction.

8. **(a)**

9. **(c) :** As the electronegativity of element increases, acidic character of oxides increases. So, in a group, basic nature increases on moving down and decreases along a period.

10. **(a) :** All are isoelectronic species but as number of protons *i.e.*, atomic number increases, the attraction between electron (to be removed) and nucleus increases and thus ionisation enthalpies increase in the order : Te^{2-} (52) < I^- (53) < Cs^+ (55) < Ba^{2+} (56).

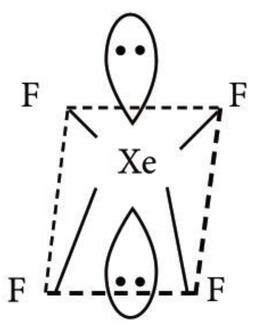
11. **(c) :**  has zero dipole moment.

trans-Butene-2

12. **(a)**

13. **(c) :** Silver belongs to fifth period. So, the atomic number of elements placed above and below will be 47 – 18 = 29 and 47 + 32 = 79 respectively.

14. **(d) :** In XeF_4, there are two lone pairs.



15. **(d) :** Larger the size of anion, greater the polarisability.
Thus, $I^- > Br^- > Cl^- > F^-$ (polarisability order).

16. **(d) :** $Be_2(8) : KK\,\sigma(2s)^2\,\sigma^*(2s)^2$
$O_2(16) : KK\sigma(2s)^2\,\sigma^*(2s)^2\,\sigma(2p_z)^2\pi(2p_x)^2\,\pi(2p_y)^2\,\pi^*(2p_x)^1\,\pi^*(2p_y)^1$
$N_2(14) : KK\,\sigma(2s)^2\,\sigma^*(2s)^2\,\pi(2p_x)^2\,\pi(2p_y)^2\,\sigma(2p_z)^2$
$C_2(12) : KK\,\sigma(2s)^2\,\sigma^*(2s)^2\,\pi(2p_x)^2\,\pi(2p_y)^2$
Therefore, C_2 contains 2 π bonds as it has 4 electrons in two pi-molecular orbitals.

17. **(a) :** Because of small size of Li^+.

18. **(a) :** Na and Mg is not an exception because there is no half-filled or completely filled orbital in them.

19. **(a) :** *E.A.* of Cl is maximum.

20. **(c) :** No. of π bonds = 3 No. of σ bonds = 12
$\text{Ratio} = \frac{3}{12} = 1 : 4$

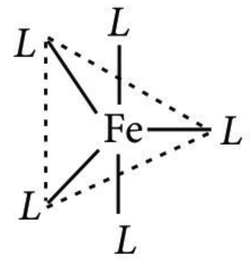
21. **(d) :** The electronic configuration of the elements are :
$_4Be$ - $1s^2\,2s^2$; $_{11}Na$ - $1s^2\,2s^2\,2p^6\,3s^1$
$_{19}K$ - $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,4s^1$
The first ionization energy of Be is maximum because electron is to be drawn from stable (fully filled) orbital. The 1^{st} ionization energy of Na is greater than K because size of K is bigger than Na which facilitates easy removal of electron from its outermost shell. So the sequence is K < Na < Be.

22. **(a) :** Dipole moment (μ) is zero for symmetrical molecules *i.e.*, $\mu_{CCl_4} = \mu_{CH_4} = 0$ but $\mu_{CHCl_3} > 0$.

23. **(a)**

24. **(b) :** O_2^- : $KK(\sigma 2s)^2\,(\sigma^*2s)^2\,(\sigma 2p_z)^2\,(\pi p_x)^2\,(\pi 2p_y)^2\,(\pi^*2p_x)^2\,(\pi^*2p_y)^1$

25. **(d) :** (a) One F atom must occupy axial position.
(b) Two F atoms occupy axial positions. One F atom occupies equatorial position.
(c) One F atom occupies any position around central atom because all the positions are identical in octahedral.

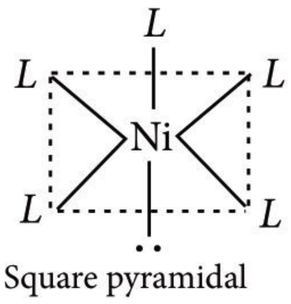
26. **(20) :** 

Trigonal bipyramidal

1 *L-M-L* = 180°
6 *L-M-L* = 60°
3 *L-M-L* = 120°
10 *L-M-L* angles

MONTHLY TEST DRIVE CLASS XII ANSWER KEY

1.	(c)	**2.**	(c)	**3.**	(b)	**4.**	(c)	**5.**	(d)
6.	(b)	**7.**	(d)	**8.**	(b)	**9.**	(d)	**10.**	(a)
11.	(d)	**12.**	(c)	**13.**	(c)	**14.**	(c)	**15.**	(c)
16.	(b)	**17.**	(d)	**18.**	(a)	**19.**	(a)	**20.**	(b,c)
21.	(a,b,c)	**22.**	(a,b,d)	**23.**	(a,b,c)	**24.**	(2)	**25.**	(5)
26.	(1)	**27.**	(a)	**28.**	(c)	**29.**	(b)	**30.**	(b)



8 *L-M-L* = 90°
2 *L-M-L* = 180°
10 *L-M-L* angles

Square pyramidal

∴ Sum of *L-M-L* angles = 20

27. (16.83) : $\mu_{ionic} = q \times d$

$= 4.8 \times 10^{-10}$ e.s.u. $\times 1.275 \times 10^{-8}$ cm

$= 6.12 \times 10^{-18}$ e.s.u. cm = 6.12 D

% Ionic character

$$= \frac{\text{Observed dipole moment}}{\text{Dipole moment for complete ionic character}} \times 100$$

$$= \frac{1.03}{6.12} \times 100 = 16.83\%$$

28. (3.87) : $\chi_F - \chi_H = 0.208\,[E_{H-F}\,(E_{F-F} \times E_{H-H})^{1/2}]^{1/2}$

$\chi_F - 2.1 = 0.208\,[134.6 - (36.6 \times 104.2)^{1/2}]^{1/2}$

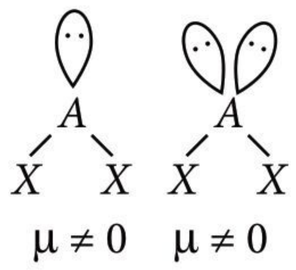
$= 0.208\,[134.6 - 61.75]^{1/2} + 2.1$

$= 0.208 \times 8.53 + 2.1 = 1.77 + 2.1 = 3.87$

29. (7) : Bond orders :

$Li_2 = 1,\ He_2^+ = 0.5, N_2^+ = 2.5, N_2^{2-} = 2, O_2^+ = 2.5,$

$O_2^{2-} = 1.0, O_2^- = 1.5, CO_3^{2-} = 1.33, C_6H_6 = 1.5, O_3 = 1.5$

30. (0) : $X - A - X$ $\quad$ 

$\mu = 0$ $\quad$ $\mu \neq 0$ $\quad$ $\mu \neq 0$

3 Amazing Facts You Must Know

1

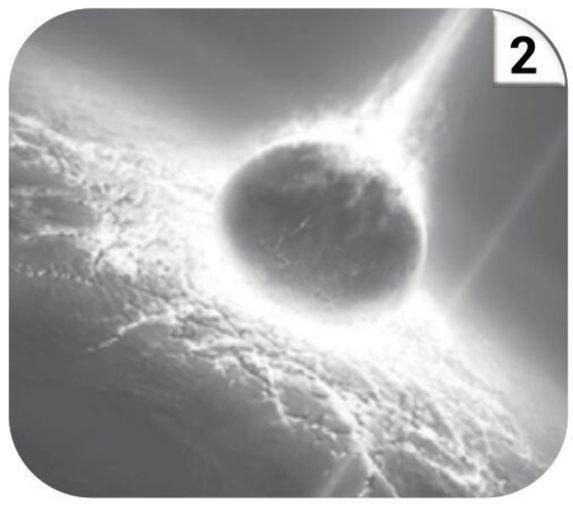
Gold does not rust

Gold is a noble metal which is chemically inert and does not rust in natural or industrial environments. This is because gold does not react with oxygen. Gold may tarnish due to : (i) Perspiration (ii) Exposure to perfumes and deodorants (iii) Leakage of acid-base cleaning solution.

But higher the karat of the gold in jewellery lower the possibility of tarnishing. Pure gold of 24 Karat does not tarnish no matter how much time passes.

In 2.3 billion years it will be too hot for life to exist on Earth

Over the coming hundreds of millions of years, the Sun will continue to get progressively brighter and hotter. In just over 2 billion years, temperatures will be high enough to evaporate our oceans, making life on Earth impossible. Our planet will become a vast desert similar to Mars today. As it expands into a red giant in the following few billion years, scientists predict that the Sun will finally engulf Earth altogether, spelling the definite end for our planet.



3 **STOMACH ACID IS STRONG ENOUGH TO DISSOLVE STAINLESS STEEL**

Stomach acid is strong enough to dissolve stainless steel

The pH of a healthy stomach is usually 1.0-2.0. This low pH level of stomach fluids typically keeps it free of microbes. But at the same time, these pH levels put stomach acid in almost the same category as battery acid, which can dissolve steel. This acid also attacks your stomach lining, which protects itself by secreting an alkali bicarbonate solution. The lining still needs to be replaced continually, and it entirely renews itself every four days.

CBSE warm-up!

CLASS-XI

Chapterwise practice questions for CBSE Exam as per the latest pattern

Unit 2 Classification of Elements and Periodicity in Properties | Chemical Bonding and Molecular Structure

General Instructions : Read the following instructions carefully.

(a) Q. No. 1 to 30 are objective type questions containing MCQs, Case Based MCQs and Assertion & Reason and very short answer questions carrying 1 mark each.

(b) Q. No. 31 to 35 are short answer-I questions carrying 2 marks each.

(c) Q. No. 36 to 38 are short answer-II questions carrying 3 marks each.

(d) Q. No. 39 to 40 are long answer questions carrying 5 marks each.

MCQs

1. The hydrides of the first elements in groups 15-17, namely NH_3, H_2O and HF respectively show abnormally high values for melting and boiling points. This is due to

(a) small size of N, O and F

(b) the ability to form extensive intermolecular H-bonding

(c) the ability to form extensive intramolecular H-bonding

(d) effective van der Waals' interaction.

2. An element forms diatomic molecule with a triple bond. The configuration of the element may be

(a) $1s^2 2s^2 2p^5$ (b) $1s^2 2s^2 2p^6$

(c) $1s^2 2s^2 2p^3$ (d) $1s^2 2s^2 2p^4$

3. The hybridization of S-atom in SO_2 is

(a) sp^3 (b) sp^3d

(c) sp (d) sp^2

4. The increasing order of the ionic radii of the given isoelectronic species is

(a) $S^{2-}, Cl^-, Ca^{2+}, K^+$ (b) $Ca^{2+}, K^+, Cl^-, S^{2-}$

(c) $K^+, S^{2-}, Ca^{2+}, Cl^-$ (d) $Cl^-, Ca^{2+}, K^+, S^{2-}$

5. Which of the following is the largest in size?

(a) Cl^- (b) S^{2-} (c) Na^+ (d) F^-

6. Which of the *d*-orbital is used in sp^3d hybridization?

(a) d_{xy} (b) $d_{x^2-y^2}$

(c) d_{z^2} (d) d_{yz}

7. Which of the following elements has the highest value of electron affinity?

(a) O (b) S (c) Se (d) Te

8. In case of heteronuclear diatomics of the type *AB*, where *A* is more electronegative than *B*, bonding molecular orbital resembles the character of *A* more than that of *B*. The statement

(a) is false

(b) is true

(c) cannot be evaluated since data is not sufficient

(d) is true only for certain systems.

9. When two ice blocks are pressed together, it forms a single block of ice due to
(a) H-bonding
(b) van der Waals forces
(c) covalent bonding
(d) electrovalent bonding.

10. The second ionisation energies of Li, Be, B and C are in the order
(a) Li > C > B > Be (b) Li > B > C > Be
(c) B > C > Be > Li (d) Be > C > B > Li

CASE BASED

Case - I : Read the passage given below and answer the following questions :

Atomic radii is defined as the distance between the nucleus and outermost shell of an ion or it is the distance between the nucleus and the point where the nucleus exerts its influence on the electron cloud.

Metal ions are smaller than the atoms from which they are formed.

When a positive ion is formed, the number of positive charges on the nucleus exceeds the number of orbital electrons, and the effective nuclear charge (which is the number of charges on the nucleus to the number of electrons) is increased. This results in the remaining electrons being more strongly attracted by the nucleus. These electrons are pulled in further reducing the size.

A positive ion is thus always smaller than the corresponding atom, and the more electrons which are removed, the smaller the ion becomes.

The negative ion is always larger than that of the corresponding atom. Negative ion is formed by gain of one or more electrons in the neutral atom and thus number of electrons increases but magnitude of nuclear charge remains the same. Due to decrease in nuclear charge per electron, there is expansion of outer shell. Thus size of anion is increased.

The following questions are multiple choice questions. Choose the most appropriate answer.

11. Which of the following ions is smallest in size?
(a) Cl^- (b) Na^+
(c) Mg^{2+} (d) S^{2-}

12. The ionic radii of N^{3-}, O^{2-}, F^-, Na^+ follow the order
(a) $N^{3-} > O^{2-} > F^- > Na^+$
(b) $N^{3-} > Na^+ > O^{2-} > F^-$
(c) $Na^+ > O^{2-} > N^{3-} > F^-$
(d) $O^{2-} > F^- > Na^+ > N^{3-}$

13. The ions O^{2-}, F^-, Na^+, Mg^{2+} and Al^{3+} are isoelectronic. Their ionic radii show
(a) a decrease from O^{2-} to F^- and then increase from Na^+ to Al^{3+}
(b) a significant increase from O^{2-} to Al^{3+}
(c) a significant decrease from O^{2-} to Al^{3+}
(d) an increase from O^{2-} to F^- and then decrease from Na^+ to Al^{3+}.

14. Which of the following statements is correct?
(a) X^- ion is larger in size than X atom.
(b) X^+ ion is larger in size than X atom.
(c) X^+ and X^- ions are equal in size.
(d) X^+ ion is larger in size than X^- ion.

15. Which one of the following is correct order of the size?
(a) $I > I^- > I^+$ (b) $I^+ > I^- > I$
(c) $I > I^+ > I^-$ (d) $I^- > I > I^+$

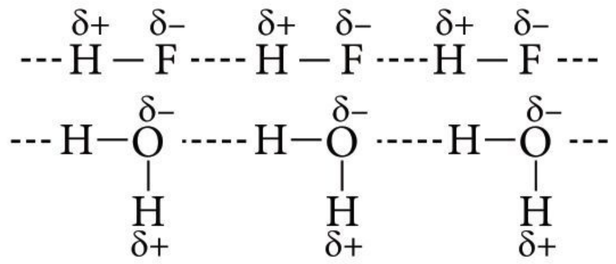
Case - II : Read the passage given below and answer the following questions :

Molecules which have H atom linked by covalent bonds to F, O or N show exceptionally high m.pt., b.pt., molecular wt., viscosity etc.

In these covalent molecules where H is linked to a highly electronegative atom, charge seggregation occurs, producing dipoles as :

$$\overset{\delta+}{H}-\overset{\delta-}{F} \quad \text{or} \quad \overset{\delta+}{H}:\overset{\delta-}{F}$$

The negative end of such a polar molecule gets attracted to the positive, H atom of the same or another molecule by a weak bond, called hydrogen bond. This bond is shown by dotted lines.



Strength of H-bond depends on the electronegativity difference between hydrogen and the electronegative atom. As electronegativity of the other bonded atom increases, strength of H-bond increases.

$$H - F > H - O > H - N$$

The following questions are multiple choice questions. Choose the most appropriate answer.

16. Which of the following compounds can form hydrogen bond?
(a) CH_4 (b) H_2O
(c) NaCl (d) $CHCl_3$

17. Which is most viscous?
(a) CH_3OH (b) $C_2H_5 - OH$
(c) $\begin{matrix} CH_2OH \\ | \\ CH_2OH \end{matrix}$ (d) None of these

18. Which one of the following molecules will form a linear polymeric structure due to hydrogen bonding?
(a) HCl (b) HF (c) H_2O (d) NH_3

19. The boiling point of methanol is greater than methyl thiol because
(a) there is intramolecular hydrogen bonding in methanol and intermolecular hydrogen bonding in methyl thiol
(b) there is intermolecular hydrogen bonding in methanol and no hydrogen bonding in methyl thiol
(c) there is no hydrogen bonding in methanol and intermolecular hydrogen bonding in methyl thiol
(d) there is no hydrogen bonding in methanol and intramolecular hydrogen bonding in methyl thiol.

20. H-bonding is not present in
(a) ammonia
(b) water
(c) hydrogen sulphide
(d) hydrogen fluoride.

ASSERTION - REASON

In the following questions (Q. No. 21 - 25) a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.
(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.
(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.
(c) Assertion is correct statement but reason is wrong statement.
(d) Assertion is wrong statement but reason is correct statement.

21. **Assertion :** Helium is placed in group 18 along with *p*-block elements.
Reason : It shows properties similar to *p*-block elements.

22. **Assertion :** Ionic bond is non-directional.
Reason : Each ion is surrounded by a uniformly distributed electric field.

23. **Assertion :** Chemistry of actinoids is more complicated than lanthanoids.
Reason : Actinoid elements are radioactive.

24. **Assertion :** Ionic compounds conduct electricity in solution as well as in molten form.
Reason : Ionic compounds are formed by sharing of electrons.

25. **Assertion :** Second ionization enthalpy will be higher than the first ionization enthalpy.
Reason : Ionization enthalpy is a quantitative measure of the tendency of an element to lose electron.

VSA

26. Name the group of the periodic table which accommodates maximum number of elements.

27. Deduce the shape of SF_4 molecule on the basis of VSEPR theory.

28. How many sigma bonds and pi bonds are present in the following compound
$CH_3—C\equiv C—COOH$?

29. Write the IUPAC name for the element with atomic number 106.

30. Ethene molecule is trigonal planar. Give reason.

SA - I

31. Can a π bond be formed without the formation of a sigma (σ) bond? How many σ and π bonds are formed in acetylene?

32. Define ionization enthalpy. Why is second ionization enthalpy always greater than the first ionization enthalpy?

33. Explain why PCl_5 is trigonal bipyramidal whereas IF_5 is square pyramidal.

34. What is meant by lanthanoids and actinoids? To which series do man-made elements belong?

35. Which properties of the elements depend on the electronic configuration of the atoms and which do not?

SA - II

36. **(a)** First ionization energy of carbon atom is greater than that of boron whereas the reverse is true for second ionization energy. Explain.
(b) Why alkali metals do not form dipositive ions?

37. What is hybridisation? What will be the state of the hybridisation of the central atom in each of the following species? PCl_5, CCl_4, $[Ni(CO)_4]$, BF_3.

38. Explain how valence bond theory differs from the Lewis concept.

LA

39. (a) Elements *A*, *B*, *C* and *D* have atomic numbers 12, 19, 29 and 36 respectively. On the basis of electronic configuration, write to which group of the periodic table each element belongs.
(b) Predict the blocks to which these elements can be classified. Also predict their periods and groups.
(c) Which of these are representative elements?

40. On the basis of hybridisation, discuss the structure of the following :
(i) PF_5 (ii) C_2H_2 (iii) SF_6
(iv) $[PtCl_4]^{2-}$ (v) BrF_5
Also draw the structure.

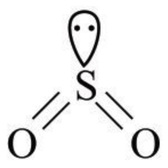
SOLUTIONS

1. **(b) :**

Atom	Electronegativity in Pauling scale
F	4.0
O	3.5
N	3.0

Thus, NH_3, H_2O and HF can form extensive intermolecular H-bonding.

2. **(c) :** The element in option (c) is nitrogen which forms triple bond.

3. **(d) :** 

Bent structure
sp^2-hybridization

4. **(b) :** For isoelectronic species as effective nuclear charge increases, ionic radii decreases. Nuclear charge is maximum of the species with maximum protons. Order of nuclear charge :

	Ca^{2+} >	K^+ >	Cl^- >	S^{2-}
Protons :	20	19	17	16
Electrons :	18	18	18	18

Thus, increasing order of ionic radii : $Ca^{2+} < K^+ < Cl^- < S^{2-}$

5. **(b) :** The increasing order of the size of the ions is : $Na^+ < F^- < Cl^- < S^{2-}$

6. **(c) :** sp^3d = one s + $3p$ + $1d$ (d_{z^2}) orbitals.

7. **(b) :** In group 16, value of electron affinity decreases down the group from S to Po. Oxygen has lowest electron affinity due to its small size which makes electron density high and repels the incoming electron.

8. **(b) :** BMOs resemble with the more electronegative atom. More electronegative atoms are lower in energy and this is due to the hold on the electrons by the nucleus.

9. **(a)**

10. **(b) :** Li – $1s^2\ 2s^1$, B – $1s^2\ 2s^2\ 2p^1$
C – $1s^2\ 2s^2\ 2p^2$, Be – $1s^2\ 2s^2$
After removing one electron, the configuration of Li, B, C and Be becomes $1s^2$, $1s^2\ 2s^2$, $1s^2\ 2s^2\ 2p^1$ and $1s^2\ 2s^1$ respectively. Hence the order of $I.E._2$ will be Li > B > C > Be.

11. **(c) :** For isoelectronic species (Mg^{2+} and Na^+) size decrease with increase of nuclear charge. Thus Mg^{2+} is smallest in size.

12. **(a) :** Ionic radii of isoelectronic species increase with decrease in nuclear charge. Thus, order is $N^{3-} > O^{2-} > F^- > Na^+$.

13. **(c) :** Ionic radii of isoelectronic ions decrease with increase of nuclear charge thus it shows a decrease from O^{2-} to Al^{3+}.

14. **(a) :** Anions are larger in size than their parent atom.

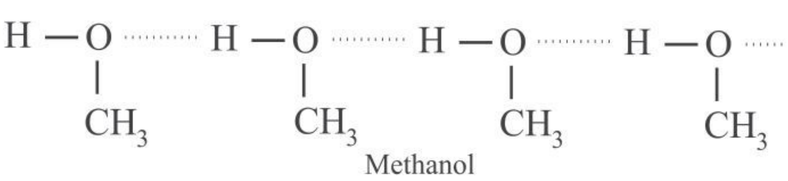
15. **(d) :** Anion has larger size and cation has smaller size than parent atom.

16. **(b) :** Oxygen has high electronegativity and small size, thus forms H-bond.

17. **(c) :** Extent of H-bonding is maximum in glycol.

18. **(b) :** HF forms linear polymeric structure due to hydrogen bonding.

.....H – F.....H – F.....H – F.....H – F.....

19. **(b) :** 
Methanol
There is no H-bonding in methyl thiol, CH_3SH.

20. **(c) :** H-bonding does not exist in H_2S because of large size and low electronegativity of sulphur.

21. **(c) :** He ($1s^2$) should be placed along with *s*-block elements but because of completely filled valence shell, it exhibits properties characteristic of noble gases, hence, it is placed along with noble gases ($ns^2\ np^6$).

22. **(a) :** Each ion, because of uniformly distributed electric field, is non-directional.

23. **(b) :** Actinoids are more complicated due to the possibility of large number of oxidation states.

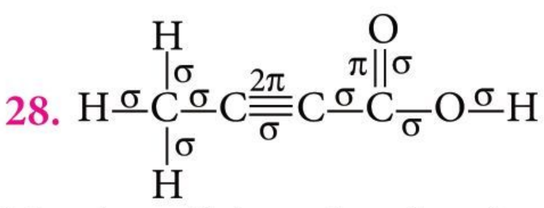
24. **(c) :** Cations and anions are attracted towards each other by the electrostatic force of attraction and are thus linked together by an ionic bond. In solution or molten state, ions separate and thus conduct electricity.

25. (b) : It is difficult to remove an electron from a positively charged ion than a neutral atom, so, second ionisation enthalpy is greater than first ionisation energy.

26. 3rd group.

27. In SF_4, there are four bonded pair of electrons and one lone pair of electrons. It has see-saw shape so as to have minimum repulsion.

28.



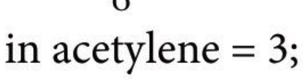
Number of sigma bonds = 9
Number of pi bonds = 3

29. Seaborgium (Sg)

30. The hybridisation of C atoms in ethene molecules is sp^2. Thus, it is trigonal planar in shape.

31. No, π bond cannot be formed without the formation of σ bond.

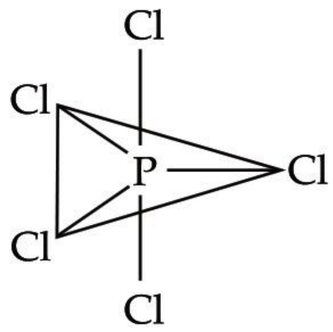
C_2H_2 :



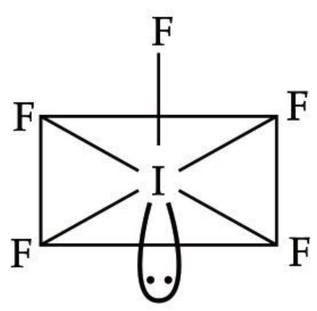
σ-bonds in acetylene = 3; π-bonds in acetylene = 2

32. A quantitative measure of the tendency of an element to lose electron is given by its ionization enthalpy. The second ionization enthalpy will be higher than the first ionization enthalpy because it is more difficult to remove an electron from a positively charged ion than from a neutral atom.

33. PCl_5 is trigonal bipyramidal since P has no lone pair of electrons in PCl_5. Three bonds are in one plane with bond angle 120° and two bonds on other plane (below and above the equatorial plane) with bond angle 90°. The type of hybridisation is sp^3d. IF_5 has sp^3d^2 hybridisation and is square pyramidal due to presence of a lone pair of electrons.



Trigonal bipyramidal



Square pyramidal

34. The fourteen elements from $_{58}Ce$ – $_{71}Lu$ in which 4*f*-subshell is being progressively filled up are called lanthanoids or rare earth elements. Similarly, the fourteen elements from $_{90}Th$ – $_{103}Lr$ in which 5*f*-subshell is being progressively filled up are called actinoids. Man-made elements belong to actinoid series.

35. Chemical and many physical properties of the elements depend on the electronic configuration of the atoms, whereas the nuclear properties do not.

36. (a) Electronic configuration of C : $1s^2, 2s^2, 2p^2$
Electronic configuration of B : $1s^2, 2s^2, 2p^1$
The first ionization energy of C will be higher than that of B, this is simply because the size of C is smaller than that of B. Thus, the valence electron of C atom feels greater nuclear charge as compare to the valence electron of B. So, it requires higher energy to remove the valence electron of C atom.
After removal of one electron,
$C^+ : 1s^2\ 2\ s^2\ 2p^1$ and $B^+\ 1s^2\ 2s^2$
B^+ is extra stable due to fully filled electronic configuration. Thus, removal of electron from B^+ is difficult thus have higher ionization enthalpy than C^+.
(b) The alkali metals after loss of one electron achieve stable configuration of noble gases. The removal of second electron requires very high energy, hence, alkali metals do not form dipositive ion.

37. It is the hypothetical phenomenon of intermixing of orbitals of same atom with slightly different energies resulting in the formation of same number of new orbitals with equal energies and shape.
Hybridisation of P in PCl_5 : sp^3d
Hybridisation of C in CCl_4 : sp^3
Hybridisation of Ni in $[Ni(CO)_4]$: sp^3
Hybridisation of B in BF_3 : sp^2

38. The Lewis concept describes the formation of bond in terms of sharing one or more electron pairs and the octet rule. It does not explain the energetics of the bond formation, and shapes of the polyatomic molecules.
The valence bond theory describes the bond formation in terms of hybridisation and overlap of the orbitals. The overlap of orbitals along the internuclear axis increases the electron-density between the two nuclei resulting in a decrease in the energy and formation of a bond.

39. (a)

Element	At. No.	Electronic configuration	Group
A	12	$1s^2 2s^2 2p^6 3s^2$	2
B	19	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$	1
C	29	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$	11
D	36	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$	18

(b) **(i)** *A* receives the last electron in 3*s*-subshell, therefore, it belongs to *s*-block.

Period = 3^{rd}

Group = No. of valence electrons = 2

(ii) *B* receives the last electron in 4*s*-orbital, therefore, it belongs to *s*-block.

Period = 4^{th}

Group = No. of valence electrons = 1

(iii) *C* receives the last electron in 3*d*-orbitals, therefore, it belongs to *d*-block.

Period = 4^{th}

Group = No. of electrons in $ns + (n-1)d$ subshells = 11

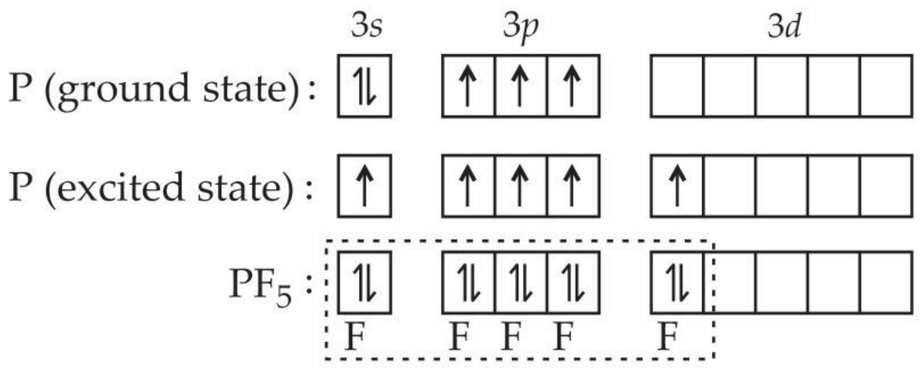
(iv) *D* receives the last electron in the 4*p*-orbital, therefore, it belongs to *p*-block.

Period = 4^{th}

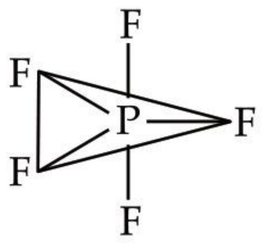
Group = 10 + valence electrons = 10 + 8 = 18

(c) The elements *A*, *B* and *C* are representative elements.

40. **(i)** Formation of PF_5 (sp^3d hybridisation)

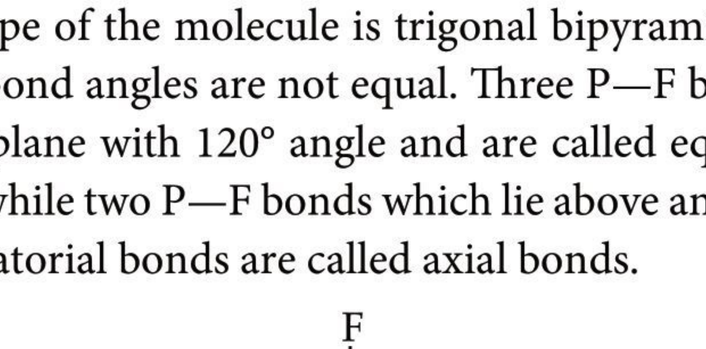


The shape of the molecule is trigonal bipyramidal and all the bond angles are not equal. Three P—F bonds lie in one plane with 120° angle and are called equatorial bonds while two P—F bonds which lie above and below the equatorial bonds are called axial bonds.



(ii) Each C-atom is *sp*-hybridised in C_2H_2.

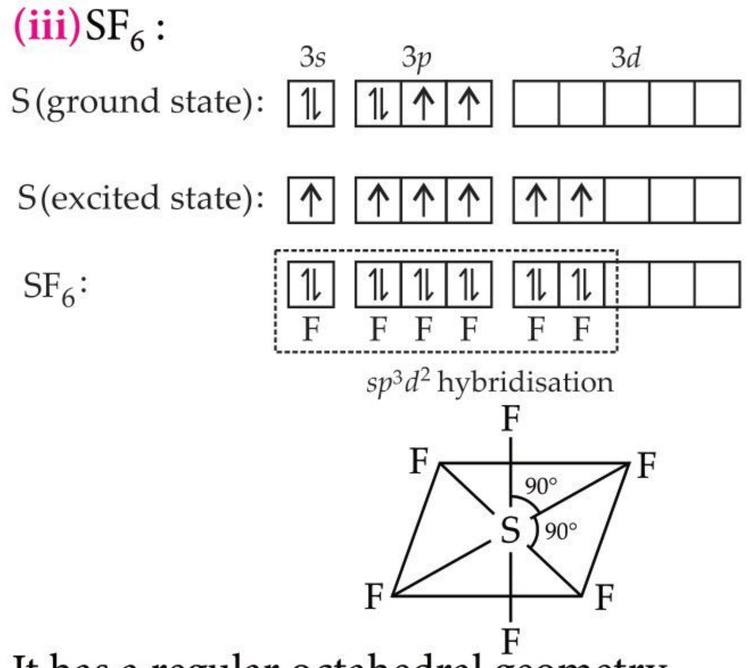
C_2H_2 molecule :



H—C≡C—H

(Formation of acetylene molecule)

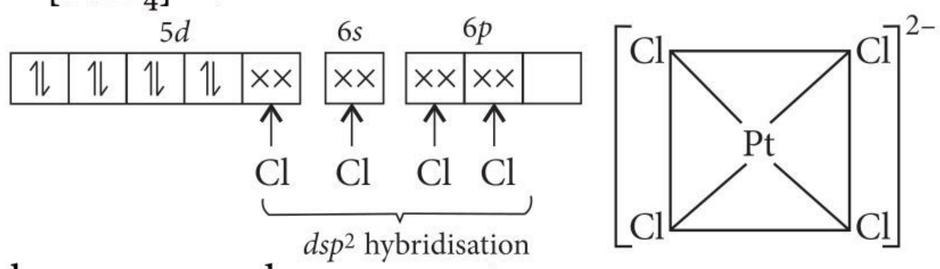
(iii) SF_6 :



It has a regular octahedral geometry.

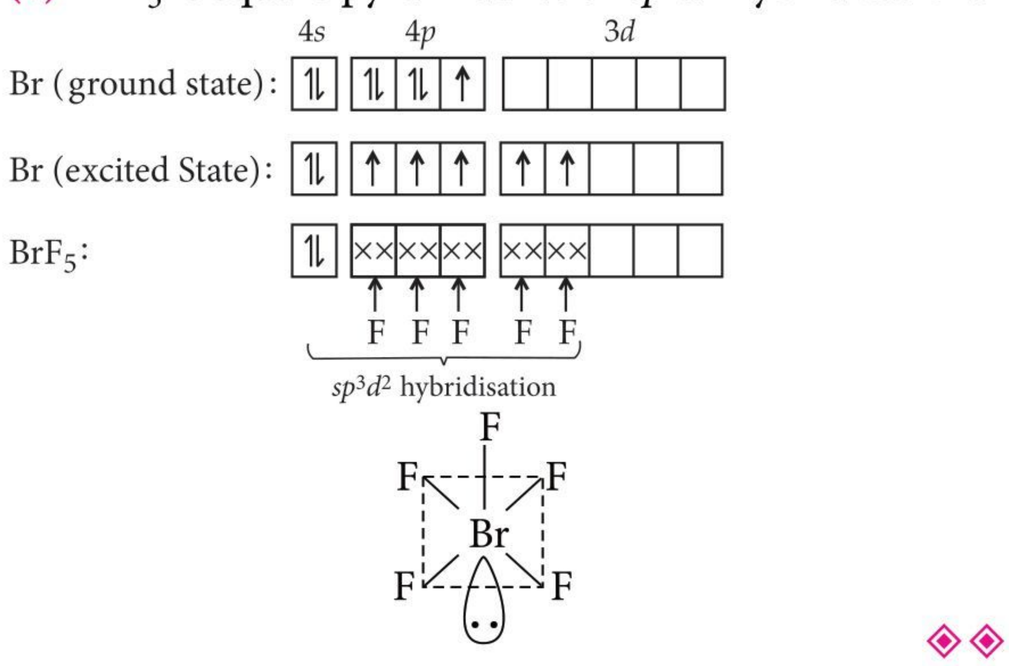
(iv) $[PtCl_4]^{2-} \Rightarrow Pt^{2+} : [Xe]4f^{14}5d^8$

$[PtCl_4]^{2-}$:



It has a square planar geometry.

(v) BrF_5 is square pyramidal with sp^3d^2 hybridisation.



MONTHLY TEST DRIVE

This specially designed column enables students to self analyse their extent of understanding of specified chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

Total Marks : 120 **Hydrocarbons | Environmental Chemistry** Time Taken : 60 Min.

NEET

Only One Option Correct Type

1. Converting *n*-hexane into benzene in the presence of chromium oxide on alumina support is an example of a/an
(a) hydrogenation reaction
(b) isomerisation reaction
(c) dehydrogenation reaction
(d) substitution reaction.

2. Which one of the following statements regarding photochemical smog is not correct?
(a) Photochemical smog is formed by the combination of smoke, dust and fog containing sulphur dioxide from polluted air.
(b) Photochemical smog does not cause irritation in eyes and throat.
(c) Carbon monoxide does not play any role in photochemical smog formation.
(d) Photochemical smog is oxidising in nature.

3. 5 L aqueous solution is kept in the presence of oxygen and suitable microorganism for five days at 20 °C. If the O_2 consumed is 0.2 g, the BOD value of the sample is
(a) 4 ppm (b) 0.4 ppm
(c) 40 ppm (d) 20 ppm

4. Identify *Z* in the sequence of reactions :

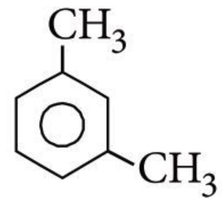
$$CH_3CH_2CH=CH_2 \xrightarrow{HBr/H_2O_2} Y \xrightarrow{C_2H_5ONa} Z$$

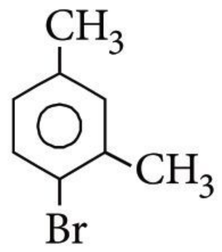
(a) $CH_3(CH_2)_3OCH_2CH_3$
(b) $(CH_3)_2CHOCH_2CH_3$
(c) $CH_3(CH_2)_4OCH_3$
(d) $CH_3CH_2CH(CH_3)OCH_2CH_3$

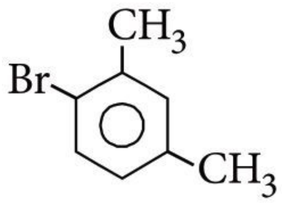
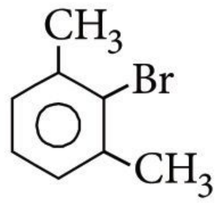
5. Which of the following organic compounds has same hybridization as its combustion product (CO_2)?
(a) Ethane (b) Ethyne
(c) Ethene (d) Ethanol

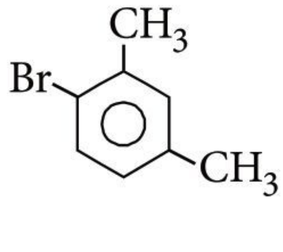
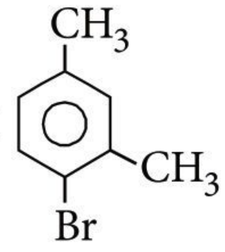
6. Peeling of ozone umbrella is due to
(a) CFCs (b) PAN
(c) CO_2 (d) coal burning.

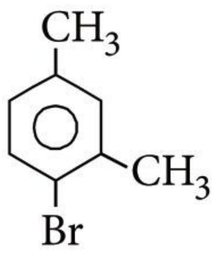
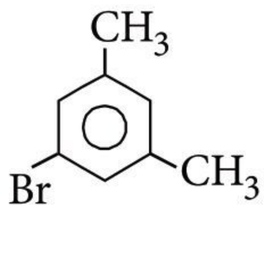
7. What products are formed when the following compound is treated with Br_2 in the presence of $FeBr_3$?

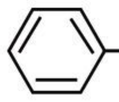


(a)  and 

(b)  and 

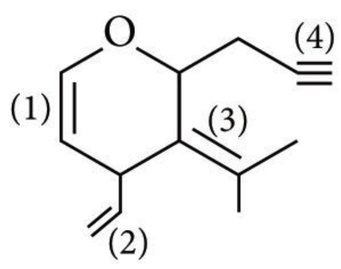
(c)  and 

(d)  and 

8. The radical,  is aromatic because it has

(a) 7 *p*-orbitals and 7 unpaired electrons
(b) 6 *p*-orbitals and 7 unpaired electrons
(c) 6 *p*-orbitals and 6 unpaired electrons
(d) 7 *p*-orbitals and 6 unpaired electrons.

9. The correct reactivity order of the labelled bonds towards Br^+ is



(a) 4 > 3 > 2 > 1 (b) 3 > 2 > 1 > 4
(c) 1 > 3 > 4 > 2 (d) 1 > 3 > 2 > 4

10. Soil salinity can be measured by

(a) calorimeter (b) potometer
(c) porometer (d) conductivity meter.

11. Some *meta*-directing substituents in aromatic substitution are given. Which one is most deactivating?

(a) $-COOH$ (b) $-NO_2$
(c) $-C \equiv N$ (d) $-SO_3H$

12. Propyne and propene can be distinguished by

(a) conc. H_2SO_4 (b) Br_2 in CCl_4
(c) dil. H_2SO_4 (d) $AgNO_3$ in ammonia.

Assertion & Reason Type

Directions : In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as :

(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

13. **Assertion :** Cyclopentadienyl anion is much more stable than allyl anion.
Reason : Cyclopentadienyl anion is aromatic in character.

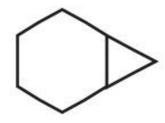
14. **Assertion :** Classical smog is oxidising smog whereas photochemical smog is reducing smog.
Reason : Classical smog occurs in warm, dry and sunny climate whereas photochemical smog occurs in cool humid climate.

15. **Assertion :** *trans*-Pent-2-ene is polar but *trans*-but-2-ene is non-polar.
Reason : The polarity of *cis*-isomer is more than *trans*-isomer.

JEE MAIN / JEE ADVANCED

Only One Option Correct Type

16. The correct name for the following hydrocarbon is



(a) tricyclo [4.1.0] heptane
(b) bicyclo [5.2.1] heptane
(c) bicyclo [4.1.0] heptane
(d) bicyclo [4.1.0] hexane.

17. Which of the following elements will cause mottling of teeth if present in drinking water?

(a) Mercury (b) Fluorine
(c) Boron (d) Chlorine

18. The chemical entities present in thermosphere of the atmosphere are

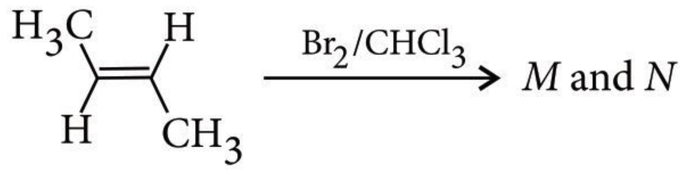
(a) O_2^+, O^+, NO^+ (b) O_3
(c) N_2, O_2, CO_2, H_2O (d) O_3, O_2^+, O_2

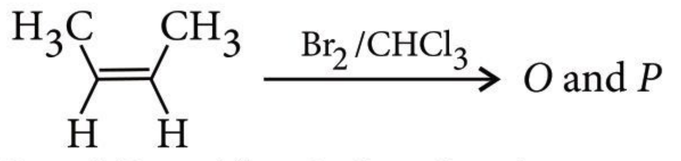
19. Which one of the following heptanols can be dehydrated to hept-3-ene only?

(a) Heptan-3-ol (b) Heptan-4-ol
(c) Heptan-2-ol (d) Heptan-1-ol

More than One Options Correct Type

20. The correct statement(s) for the following addition reactions is(are)

(i) 

(ii) 

(a) *O* and *P* are identical molecules
(b) bromination proceeds through *trans*-addition in both the reactions
(c) (*M* and *O*) and (*N* and *P*) are two pairs of enantiomers
(d) (*M* and *O*) and (*N* and *P*) are two pairs of diastereomers.

Quotable Quote

"I believe that the science of chemistry alone almost proves the existence of an intelligent creator."

Thomas A. Edison

21. Which of the following is a sink for CO?
(a) Microorganisms present in the soil
(b) Oceans
(c) Plants
(d) Haemoglobin

22. Which of the following pollutants is emitted during volcanic eruptions?
(a) SO_2 (b) H_2S
(c) Hydrocarbons (d) CO

23. Which of the following is the correct match?
(a) $Be_2C + H_2O \rightarrow$ Marsh gas
(b) $Al_4C_3 + H_2O \rightarrow$ Component of CNG
(c) $CaC_2 + H_2O \rightarrow$ Used for welding purpose with O_2 gas
(d) $Mg_2C_3 + H_2O \rightarrow$ Used as a rocket fuel

Integer / Numerical Value Type

24. How many compounds are formed upon the ozonolysis followed by hydrolysis of the following triyne?

25. How many acids given below are present in acid rain?
H_2CO_3, $HClO_4$, H_2SO_4, HNO_3, HCl, H_3PO_4, CH_3COOH

26. How many structures are possible for C_5H_8 with one triple bond?

Comprehension Type

In the following sequence of reactions, the products (*A*) to (*E*) are formed :

(i) $2CH_{4(g)} \xrightarrow[1773\ K]{\Delta} A_{(g)} + B_{(g)}$

(ii) 4 mol of $(A) \xrightarrow[\Delta]{Ni(CN)_4 / THF} (C) \xrightarrow{O_3/oxid.} (D)$ only

(iii) $(A) \xrightarrow[(ii)\ C_2H_5I]{(i)\ 1mol\ of\ NaNH_2} (E)$

27. Compound '*D*' is
(a) glyoxal (b) glycol
(c) oxalic acid (d) methylglyoxal.

28. Compound '*E*' is
(a) propyne (b) butyne
(c) but-2-yne (d) ethyne.

Matrix Match Type

29. Match list I (reagents used with ethyne) with list II (products) and select the correct answer using the codes given below the lists.

	List I		**List II**
P.	Hydrogen in presence of Pt/Pd/Ni	(i)	Benzene
Q.	Heat at 600 °C in Cu-tube	(ii)	Acetaldehyde
R.	Hydrogen in presence of Pd and $CaCO_3$ at 473 K	(iii)	Ethene
S.	Water in presence of H_2SO_4 and $HgSO_4$	(iv)	Ethane

	P	**Q**	**R**	**S**
(a)	(ii)	(iii)	(iv)	(i)
(b)	(i)	(iv)	(iii)	(ii)
(c)	(i)	(iv)	(ii)	(iii)
(d)	(iv)	(i)	(iii)	(ii)

30. Match the processes given in List I with reagents mentioned in List II and choose the correct answer using the codes given below :

	List I		**List II**
P.	Dehydrohalo-genation	1.	O_2/Δ, Ag catalyst
Q.	Dehydration	2.	Alc. KOH
R.	Unsaturation	3.	Conc. H_2SO_4/170°C
S.	Epoxidation	4.	Br_2-water

	P	**Q**	**R**	**S**
(a)	3	2	4	1
(b)	2	3	4	1
(c)	4	1	3	2
(d)	3	1	2	4

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SELF CHECK

No. of questions attempted .....
No. of questions correct .....
Marks scored in percentage .....

Check your score! If your score is

> 90%	EXCELLENT WORK !	You are well prepared to take the challenge of final exam.
90-75%	GOOD WORK !	You can score good in the final exam.
74-60%	SATISFACTORY !	You need to score more next time.
< 60%	NOT SATISFACTORY!	Revise thoroughly and strengthen your concepts.

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CLASS-XII

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Unit 2

Electrochemisty | Chemical Kinetics

Electrochemisty

Electrochemical Cell

(Converts chemical energy into electrical energy in a redox reaction or vice-versa)

	Galvanic cell	Electrolytic cell
Anode	Oxidation, negative (–) terminal	Oxidation, positive (+) terminal
Cathode	Reduction, positive (+) terminal	Reduction, negative (–) terminal

Electrode Potential

- It is defined as the tendency of an electrode to gain or lose electrons when it is in contact with the solution of its own ions.

Nernst Equation

$M^{n+}_{(aq)} + ne^- \longrightarrow M_{(s)}$

$$E_{cell} = E^{\circ}_{cell} - \frac{RT}{nF} \ln \frac{[M_{(s)}]}{[M^{n+}_{(aq)}]}$$

For pure solid or liquid or gas at 1 atm pressure, the molar concentration is taken as unity; $[M] = 1$

$$E_{cell} = E^{\circ}_{cell} - \frac{2.303RT}{nF} \log \frac{1}{[M^{n+}_{(aq)}]}$$

$$E_{cell} = E^{\circ}_{cell} - \frac{0.0591}{n} \log \frac{1}{[M^{n+}_{(aq)}]}$$

- The electrode potential difference between the two half-cells is known as electromotive force (EMF) of the cell or cell potential or cell voltage.
- EMF can be calculated from the values of electrode potentials of the two half-cells constituting the cell using following methods :
  - $E^{\circ}_{cell} = E^{\circ}_{ox}$ (anode) + E°_{red} (cathode)
  - When only reduction potential is taken into account,
    $E^{\circ}_{cell} = E^{\circ}_{red}$ (cathode) – E°_{red} (anode) = $E^{\circ}_{right} - E^{\circ}_{left}$
  - When only oxidation potential is taken into account,
    $E^{\circ}_{cell} = E^{\circ}_{ox}$ (anode) – E°_{ox} (cathode)

Applications

- To calculate electrode potential of a cell :

$aA + bB \xrightarrow{ne^-} xX + yY$

$$E_{cell} = E^{\circ}_{cell} - \frac{0.0591}{n} \log \frac{[X]^x[Y]^y}{[A]^a[B]^b}$$

- To calculate equilibrium constant :
  At equilibrium, $E_{cell} = 0$

$$E^{\circ}_{cell} = \frac{0.0591}{n} \log K_c \text{ at 298 K}$$

- Relation between electrochemical cell and Gibbs energy

$\Delta G^{\circ} = -nFE^{\circ}_{cell}$; $\Delta G^{\circ} = -2.303\ RT \log K_c$

Conductance

The reciprocal of the electric resistance is called the conductance. It is usually represented by G. Thus, $G = 1/R$.

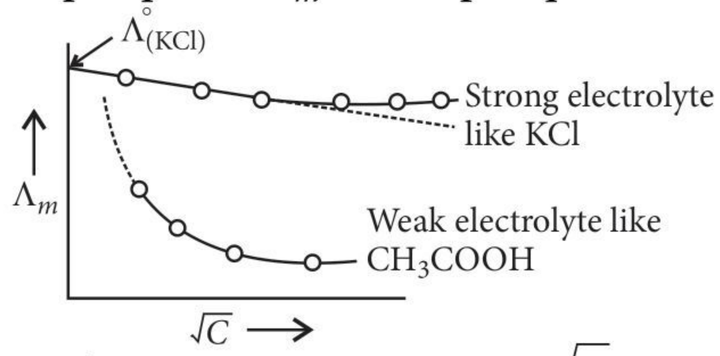
Property	Specific conductance	Equivalent conductance	Molar conductance
Definition	Reciprocal of specific resistance or conductance of solution of 1 cm length and 1 cm^2 area of cross-section.	Conductance produced by all the ions of 1 g equivalent electrolyte in a given solution.	Conduction produced by all the ions of 1 mol electrolyte in a given solution.
Representation	κ (kappa)	Λ_{eq} (lambda)	Λ_m (lambda)
Formula	$\kappa = \frac{1}{\rho} = \frac{l}{Ra} = G\frac{l}{a}$	$\Lambda_{eq} = \kappa \times V = \kappa \times \frac{1000}{\text{Normality}}$	$\Lambda_m = \kappa \times V = \kappa \times \frac{1000}{\text{Molarity}}$
Units	$ohm^{-1}\ cm^{-1}$	$ohm^{-1}\ cm^2\ eq^{-1}$	$ohm^{-1}\ cm^2\ mol^{-1}$
SI units	$S\ m^{-1}$	$S\ m^2\ eq^{-1}$	$S\ m^2\ mol^{-1}$

Variation of G, κ, Λ_m and Λ_{eq} with dilution :

- On dilution, as no. of ions increases, conductance (G) increases.
- On dilution as no. of ions per cm^3 decreases, specific conductance (κ) decreases.
- On dilution, though specific conductance decreases but volume (V) increases much more hence, equivalent conductance (Λ_{eq}) or molar conductance (Λ_m) increases.
- When concentration approaches zero *i.e.*, at infinite dilution, the molar conductivity is known as limiting molar conductivity (Λ_m°).

Variation of molar conductance with concentration (C) :

- **For strong electrolytes,** Λ_m increases slowly with dilution and can be represented by the equation :
  $\Lambda_m = \Lambda_m^\circ - AC^{1/2}$ (Debye—Huckel Onsager equation)
  Plot of Λ_m against $C^{1/2}$ is a straight line with intercept equal to Λ_m° and slope equal to '$-A$'.



  Thus, Λ_m^c decreases linearly with $\sqrt{C}$, when $C = 0$, $\Lambda_m^c = \Lambda_m^\circ$ and Λ_m° can be determined experimentally.
- **For weak electrolytes,** Λ_m^c increases as C decreases but does not reach a constant value even at infinite dilution. Hence, there Λ°_m cannot be determined experimentally.

Kohlrausch's Law

The limiting molar conductivity of an electrolyte is the sum of the limiting ionic conductivities of the cation and the anion each multiplied with the number of ions present in one formula unit of the electrolyte.

$$\Lambda^\circ_m = \lambda^\circ_+ + \lambda^\circ_-$$

λ°_+ and λ°_- are called ionic conductivities of cation and anion at infinite dilution respectively.

$$A_xB_y \longrightarrow xA^{y+} + yB^{x-}\ ;\ \Lambda^\circ_m = x\lambda^\circ_{A^{y+}} + y\lambda^\circ_{B^{x-}}$$

Applications

- Calculation of molar conductivity of weak electrolytes at infinite dilution :
  $\Lambda^\circ_{m\ (CH_3COOH)} = \lambda^\circ_{CH_3COO^-} + \lambda^\circ_{H^+}$
- The above equation can be obtained as $\Lambda^\circ_{m\ (CH_3COOH)}$
  $= \Lambda^\circ_{m\ (CH_3COONa)} + \Lambda^\circ_{m\ (HCl)} - \Lambda^\circ_{m\ (NaCl)}$
  $= \lambda^\circ_{CH_3COO^-} + \lambda^\circ_{Na^+} + \lambda^\circ_{H^+} + \lambda^\circ_{Cl^-} - \lambda^\circ_{Na^+} - \lambda^\circ_{Cl^-}$
- Calculation of degree of dissociation :
  $$\text{Degree of dissociation } (\alpha) = \frac{\Lambda^c_m}{\Lambda^\circ_m}$$
- Calculation of dissociation constant of a weak electrolyte :
  $$\text{Dissociation constant } (K_c) = \frac{C\alpha^2}{1-\alpha}$$
- Calculation of solubility of a sparingly soluble salt solutions are considered saturated at infinite dilution so, $\Lambda_m = \Lambda^\circ_m$ and molarity = solubility.

  Thus, $\Lambda^\circ_m = \frac{\kappa \times 1000}{\text{molarity}}$

  or $\text{Solubility } (mol^{-1}) = \frac{\kappa \times 1000}{\Lambda^\circ_m}$

Electrolysis

It is the process of decomposition of an electrolyte by passing electricity through its aqueous solution or molten state.

- **Faraday's first law of electrolysis :** The amount of chemical reaction which occurs at any electrode during electrolysis is proportional to the quantity of electricity passed through the electrolyte.

  $w \propto Q$ or $w = ZQ = Z \times I \times t$

  where, Z is electrochemical equivalent of the substance deposited.

  $$Z = \frac{\text{Eq. wt. of substance}}{96500}.$$

- **Faraday's second law of electrolysis :** The amounts of different substances liberated by the same quantity of electricity passing through the electrolytic solution are proportional to their chemical equivalent weights.

  $$\frac{w_1}{w_2} = \frac{E_1}{E_2}$$ where E is the equivalent weight.

Some Commercial Cells

- **Primary cells :** Cells once exhausted cannot be used again *e.g.*, dry cell and mercury cell.
- **Secondary cells :** Rechargeable cells which can be used again and again *e.g.*, nickel-cadmium storage cell and lead storage battery.
- **Fuel cells :** Cells which can convert the energy of combustion of fuels such as H_2, CO, CH_4 etc., into electrical energy *e.g.*, $H_2 - O_2$ fuel cell.

Chemical Kinetics

Rate of Chemical Reaction

- The rate of reaction is the change in the concentration of any one of the reactants or products per unit time.

$$\text{Rate} = \frac{\text{Decrease in conc. of reactant}}{\text{Time taken}} = \frac{\text{Increase in conc. of product}}{\text{Time taken}}$$

$A + B \longrightarrow C + D$

$$\text{Rate} = -\frac{\Delta[A]}{\Delta t} = -\frac{\Delta[B]}{\Delta t} = +\frac{\Delta[C]}{\Delta t} = +\frac{\Delta[D]}{\Delta t}$$

Negative sign shows decrease in concentration with time and positive sign shows increase in concentration with time.

- **Units :**

$$\text{Rate} = \frac{\text{Concentration}}{\text{Time}} = \frac{\text{mol/litre}}{\text{sec}}$$

$= \text{mol litre}^{-1}\text{sec}^{-1}$

Factors Affecting Rate of Reaction

Nature

- **Physical state :** Gaseous state > Liquid state > Solid state (Decreasing rate of reaction →)
- **Size of reactants :** As size of reactant decreases, rate of reaction increases. Rate of reaction is maximum in powdered state because of increase in surface area.
- **Chemical nature :** Rate of reaction increases if the number of bonds broken and formed in the reactions are lesser in number.
- **Concentration of reactants :** Rate of the reaction is directly proportional to concentration of the reactant.

- **Exposure to radiation :** The rate of chemical reaction is considerably increased by the use of radiations of certain frequency.
- **Catalyst :** A positive catalyst increases the reaction rate by changing the path of reaction and lowering the activation energy.
- **Surface area :** Larger the surface area of the reactants, faster is the rate of reaction.
- **Temperature :** Rate of reaction increases considerably with an increase in temperature.

Rate Law and Rate Constant (Law of Mass Action)

- The rate of reaction is proportional to the product of effective concentrations of the reacting species, each raised to a power which is equal to the corresponding stoichiometric number of the molecules appearing in the chemical reaction.

$aA + bB \longrightarrow cC + dD$

$r \propto [A]^a [B]^b$ or $r = k[A]^a [B]^b$

k is the constant of proportionality.

Rate of reaction at unit concentration of reactants is called rate constant.

Order and Molecularity of the reaction

- The sum of powers of the concentration of the reactants in the rate law expression is called the order of reaction.

For the rate law equation, Rate $= k[A]^x [B]^y$

$x + y$ gives the overall order of a reaction.

Order of a reaction can be 0, 1, 2, 3 and even a fraction.

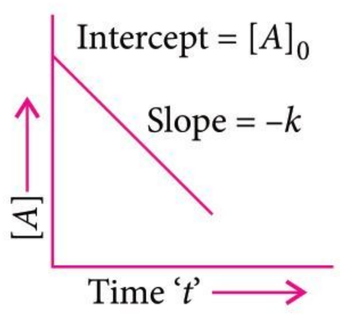
- The number of reacting species (atoms, ions or molecules) taking part in an elementary reaction, which must collide simultaneously in order to bring about a chemical reaction is called molecularity of a reaction.

For Reactions of Different Orders

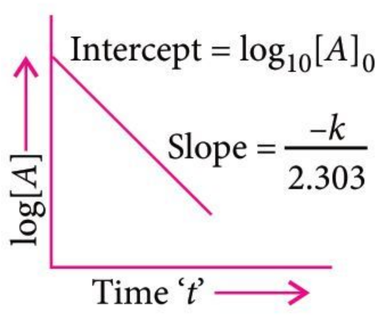
Order	Rate law	Integrated rate law	Half-life	Unit of rate constant	Graph
0	Rate $= k[A]^0$	$[A]_t = -kt + [A]_0$	$t_{1/2} = [A]_0/2k$	mol L^{-1} s^{-1}	$[A]$ *vs* t; slope $= -k$
1	Rate $= k[A]^1$	$\ln[A]_t = -kt + \ln [A]_0$	$t_{1/2} = 0.693/k$	s^{-1}	$\ln[A]$ *vs* t; slope $= -k$
2	Rate $= k[A]^2$	$1/[A]_t = kt + 1/[A]_0$	$t_{1/2} = 1/k\,[A]_0$	L mol^{-1} s^{-1}	$1/[A]$ *vs* t; slope $= k$
n	Rate $= k[A]^n$	$(n-1)kt = \frac{1}{[A]^{n-1}} - \frac{1}{[A_0]^{n-1}}$	$t_{1/2} = \frac{2^{n-1}-1}{k(n-1)[A]_0^{n-1}}$	$(\text{mol L}^{-1})^{1-n}$ s^{-1}	$\frac{1}{[A]^{n-1}}$ *vs* t; slope $= k$

Some typical linear plots for reactions of different orders :

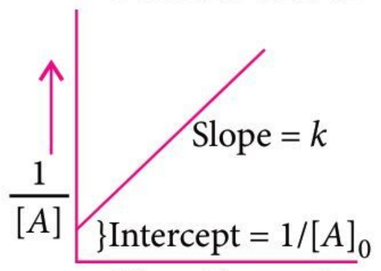
Zero order



First order



Second order



Temperature dependence of the rate of a reaction

For a chemical reaction with rise in temperature by 10 °C, the rate constant is nearly doubled.

Arrhenius equation

$k = Ae^{-E_a/RT}$ where A is pre-exponential factor (Arrhenius factor or frequency factor), E_a is activation energy and $e^{-E_a/RT}$ corresponds to the fraction of molecules that have kinetic energy equal to or greater than E_a.

$$\ln k = -\frac{E_a}{RT} + \ln A \text{ or } \log k = -\frac{E_a}{2.303RT} + \log A$$

The plot of $\log k$ *vs* $1/T$ gives a straight line with slope

$$= -\frac{E_a}{2.303\,R} \text{ and intercept} = \log A$$

$$\log \frac{k_2}{k_1} = \frac{E_a}{2.303R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$$

where, k_1 and k_2 are the values of rate constant at temperatures T_1 and T_2 respectively.

Collision Theory

- Reactions occur when molecules collide with appropriate orientation and sufficient energy, not

all molecular collisions result successfully in the formation of product.

- **For any successful collision :**
  - Particles must collide with sufficient energy > E_a.
  - They need to have correct alignment (collision geometry) to keep E_a as low as possible.
  - To account for effective collision, another factor P, called orientation factor or steric factor or probability factor is introduced.

$$k = PZ_{AB}\, e^{-E_a/RT}$$

where, Z_{AB} represents the collision frequency of reactants A and B.

WRAP it up!

1. A conductance cell when filled with 0.5 M KCl solution (conductivity = $6.67 \times 10^{-3}\ \Omega^{-1}\ cm^{-1}$) registers a resistance of 243 Ω. Its cell constant is
(a) 1.62 cm (b) $1.62\ cm^{-1}$
(c) $1.62\ dm^{-1}$ (d) $1.62\ m^{-1}$

2. If $E^{\circ}_{Fe^{2+}/Fe} = x_1$ V, $E^{\circ}_{Fe^{3+}/Fe^{2+}} = x_2$ V, what is the $E^{\circ}_{Fe^{3+}/Fe}$?
(a) $\frac{2x_1 + x_2}{4}$ (b) $\frac{2x_1 + x_2}{3}$
(c) $\frac{2x_1 + x_2}{2}$ (d) $2x_1 + x_2$

3. For a cell involving one electron, $E^{\circ}_{cell} = 0.59$ V at 298 K, the equilibrium constant for the cell reaction is [Given that $\frac{2.303RT}{F} = 0.059$ V at $T = 298$ K]
(a) 1.0×10^{30} (b) 1.0×10^{2}
(c) 1.0×10^{5} (d) 1.0×10^{10} **(NEET 2019)**

4. A radioactive element gets spilled over the floor of a room. Its half-life period is 30 days. If the initial activity is 10 times of the permissible value, after how many days it will be safe to enter the room?
(a) 1000 days (b) 300 days
(c) 10 days (d) 100 days

5. Which of the following relation is correct for zero order reaction?
(a) $t_{3/4} = 2t_{1/2}$ (b) $t_{3/4} = 1.5\ t_{1/2}$
(c) $t_{3/4} = \frac{1}{2}t_{1/2}$ (d) $t_{3/4} = \frac{1}{3}t_{1/2}$

6. The same quantity of electricity is passed through H_2SO_4 and HCl solutions of same concentration. The amount of hydrogen liberated from H_2SO_4 as compared to the from HCl is
(a) the same (b) twice as such
(c) one half as such
(d) dependent on concentration.

7. The rate constant is numerically the same for three reactions of first, second and third order respectively. Which one is true for rate of three reactions, if concentration of reactant is greater than 1 M?
(a) $r_1 = r_2 = r_3$ (b) $r_1 > r_2 > r_3$
(c) $r_1 < r_2 < r_3$ (d) All of these

8. On electrolysis of dilute sulphuric acid using platinum electrodes, the product obtained at the anode will be
(a) hydrogen
(b) oxygen
(c) hydrogen sulphide
(d) sulphur dioxide

9. Which of the following is not a non-electrolyte?
(a) Urea (b) Glucose
(c) Ethanol (d) Acetic acid

10. The rate constant, activation energy and Arrhenius parameter of a chemical reaction at 25 °C are $3.0 \times 10^{-4}\ s^{-1}$, 104.4 kJ mol^{-1} and $6.0 \times 10^{14}\ s^{-1}$ respectively. The value of the rate constant as $T \to \infty$ is
(a) $2.0 \times 10^{18}\ s^{-1}$ (b) $6.0 \times 10^{14}\ s^{-1}$
(c) infinity (d) $3.6 \times 10^{30}\ s^{-1}$

11. For the given cell;
$Cu_{(s)}|Cu^{2+}(C_1M)||Cu^{2+}(C_2M)|Cu_{(s)}$ change in Gibbs energy (ΔG) is negative, if
(a) $C_1 = C_2$ (b) $C_2 = C_1/\sqrt{2}$
(c) $C_1 = 2C_2$ (d) $C_2 = \sqrt{2}C_1$
(JEE Main 2020)

12. Standard reduction electrode potentials of three metals A, B and C are +0.5 V, −3.0 V, and −1.2 V respectively. The reducing power of these metals are
(a) $B > C > A$ (b) $A > B > C$
(c) $C > B > A$ (d) $A > C > B$

13. In the following first order competing reactions where $t_1 = t_2$:

$A + \text{Reagent} \xrightarrow{k_1} \text{Product}$

$B + \text{Reagent} \xrightarrow{k_2} \text{Product}$

The ratio of $\frac{k_1}{k_2}$ if only 50% of B and 94% of A have been reacted is

(a) 4.06 (b) 0.246 (c) 2.06 (d) 0.06

14. Reactant (A) forms two products :

$A \xrightarrow{k_1} B$ Activation energy, E_{a_1}

$A \xrightarrow{k_2} C$ Activation energy, E_{a_2}

If $E_{a_2} = 2E_{a_1}$, then k_1 and k_2 are related as

(a) $k_2 = k_1 e^{E_{a_1}/RT}$ (b) $k_2 = k_1 e^{E_{a_2}/RT}$

(c) $k_1 = Ak_2 e^{E_{a_1}/RT}$ (d) $k_1 = 2k_2 e^{E_{a_2}/RT}$

15. The decomposition of N_2O_5 is a first order reaction represented by $N_2O_5 \rightleftharpoons N_2O_4 + \frac{1}{2}O_2$. After 15 minutes the volume of O_2 produced is 9 mL and at the end of the reaction 35 mL. The rate constant is equal to

(a) $\frac{1}{15}\ln\frac{35}{26}$ (b) $\frac{1}{15}\ln\frac{44}{35}$

(c) $\frac{1}{15}\ln\frac{35}{44}$ (d) $\frac{1}{15}\ln\frac{44}{26}$

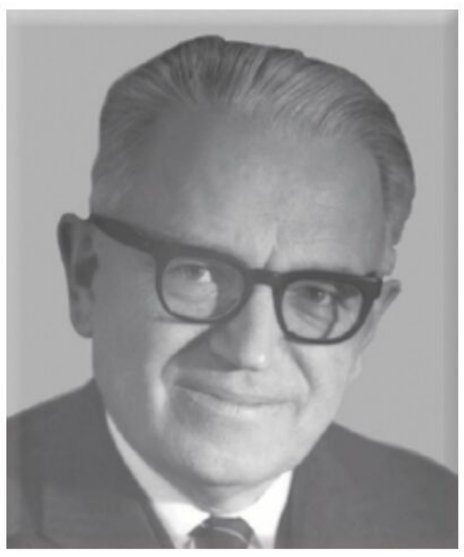
16. The rate constant for a first order reaction is $4.606 \times 10^{-3}\ s^{-1}$. The time required to reduce 2.0 g of the reactant to 0.2 g is

(a) 100 s (b) 200 s

(c) 500 s (d) 1000 s **(NEET 2020)**

Scientist of the Month

Gerhard Heinrich



Gerhard Heinrich
(25 December, 1904 - 3 March, 1999)

Early Life and Education

Herzberg was born in Hamburg, Germany. Herzberg started Vorschule (pre-school) late, after contracting measles. Gerhard and his family were atheists and kept this fact hidden. Herzberg graduated Vorschule shortly after his father's death. After completing high school at the Gelehrtenschule des Johanneums, Herzberg continued his education at Darmstadt University of Technology with the help of a private scholarship. Herzberg completed his Dr.-Ing. degree under Hans Rau in 1928. He did Post-doctoral work (1928-30) at the University of Göttingen and Bristol University under James Franck, Max Born, John Lennard-Jones.

Contributions

- 1936-45 Professor of Physics, University of Saskatchewan
- 1939 Fellow of the Royal Society of Canada
- 1945-48 Professor of spectroscopy, Yerkes Observatory, University of Chicago (Chicago, United States)
- 1948 Director of the Division of Pure Physics, National Research Council of Canada
- 1951 Fellow of the Royal Society of London
- 1957-63 Vice President of the International Union of Pure and Applied Physics
- 1956-57 President of the Canadian Association of Physicists
- 1960 gives Bakerian Lecturer of the Royal Society of London
- 1966-67 President of the Royal Society of Canada
- 1968 Companion of the Order of Canada
- 1968 George Fischer Baker Non-Resident Lecturer in Chemistry at Cornell University (Ithaca, United States)
- 1969 Distinguished Research Scientist in the recombined Division of Physics, at the National Research Council of Canada
- 1973-1980 Chancellor of Carleton University (Ottawa, Ontario, Canada)
- 1981 Founding member of the World Cultural Council.
- 1992 Sworn into the Queen's Privy Council for Canada
- Herzberg authored some classic works in the field of spectroscopy, including Atomic Spectra and Atomic Structure and the encyclopaedic four volume work: Molecular Spectra and Molecular Structure, which is often called the spectroscopist's bible.

Honors

- Herzberg's most significant award was the 1971 Nobel Prize in Chemistry, which he was awarded "for his contributions to the knowledge of electronic structure and geometry of molecules, particularly free radicals". During the presentation speech, it was noted that at the time of the award, Herzberg was "generally considered to be the world's foremost molecular spectroscopist."
- Herzberg was honoured with memberships or fellowships by a very large number of scientific societies, received many awards and honorary degrees in different countries.
- The NSERC Gerhard Herzberg Canada Gold Medal for Science and Engineering, Canada's highest research award, was named in his honour in 2000.
- The Herzberg Institute of Astrophysics is named for him.
- In 1964 he was awarded the Frederic Ives Medal by the OSA.
- Faraday medal in 1970.
- 1971 Royal Medal from Royal Society of London

17. The equivalent conductances of two strong electrolytes at infinite dilution in H_2O (where ions move freely through a solution) at 25°C are given below :

$\Lambda^\circ_{CH_3COOH} = 91.0$ S cm^2/equiv

$\Lambda^\circ_{HCl} = 426.2$ S cm^2/equiv

What additional information/quantity one needs to calculate Λ° of an aqueous solution of acetic acid?

(a) Λ° of NaCl (b) Λ° of CH_3COOK

(c) The limiting equivalent conductance of $H^+(\lambda^\circ_{H^+})$

(d) Λ° of chloroacetic acid ($ClCH_2COOH$)

18. Which of the following is not correct?

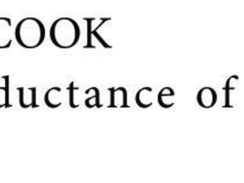
(a) Rate of zero order reaction depends upon initial concentration of reactant.

(b) Rate of zero order reaction does not depend upon initial concentration of reactant.

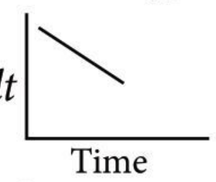
(c) $t_{1/2}$ of first order reaction is independent of initial concentration of reactant.

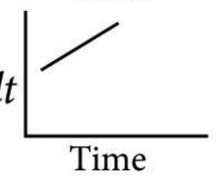
(d) $t_{1/2}$ of zero order reaction is dependent of initial concentration of reactant.

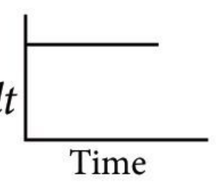
19. Graph between concentration of the product and time of the reaction ($A \rightarrow B$) is shown as :

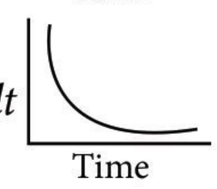


Then, graph between $-d[A]/dt$ and time will be of the type

(a) 

(b) 

(c) 

(d) 

20. The quantity of electricity needed to electrolyse completely 1 M solution of $CuSO_4$, $Bi_2(SO_4)_3$, $AlCl_3$ and $AgNO_3$ each will be

(a) 2 F, 6 F, 3 F and 1 F respectively

(b) 6 F, 2 F, 3 F and 1 F respectively

(c) 2 F, 6 F, 1 F and 3 F respectively

(d) 6 F, 2 F, 1 F and 3 F respectively

21. In the sequence of reaction, $A \xrightarrow{k_1} B \xrightarrow{k_2} C \xrightarrow{k_3} D$ $k_3 > k_2 > k_1$, then the rate determining step of the reaction is:

(a) $A \rightarrow B$ (b) $B \rightarrow C$

(c) $C \rightarrow D$ (d) $A \rightarrow D$

22. 0.1 molar NaCl solution is filled in different conductivity cells.

	Cell-1	**Cell-2**	**Cell-3**
Area of cross section (A)	5 cm^2	7.5 cm^2	10 cm^2
Distance between two electrodes (l)	2 cm	3 cm	4 cm

Order of equivalent conductance of NaCl solution is

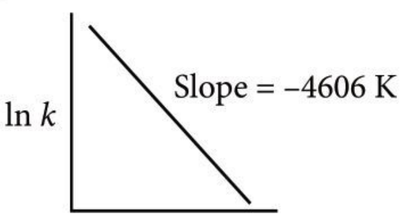
(a) Cell-1 > Cell-2 > Cell-3

(b) Cell-1 = Cell-2 = Cell-3

(c) Cell-1 > Cell-3 > Cell-2

(d) Cell-3 > Cell-2 > Cell-1

23. For a reaction, consider the plot of ln k versus $1/T$ given in the figure. If the rate constant of this reaction at 400 K is 10^{-5} s^{-1}, then the rate constant at 500 K



(a) 10^{-4} s^{-1} (b) 4×10^{-4} s^{-1}

(c) 10^{-6} s^{-1} (d) 2×10^{-4} s^{-1}

(JEE Main 2019)

24. The rate law for a reaction between the substances A and B is given by $r = k[A]^n[B]^m$. On doubling the concentration of A and halving the concentration of B, the ratio of the new rate to the earlier rate of reaction will be

(a) $\frac{1}{2^{(m+n)}}$ (b) $m + n$

(c) $n - m$ (d) $2^{(n-m)}$

25. An example of a simple fuel cell is

(a) lead storage battery (b) $H_2 - O_2$ cell

(c) Daniell cell (d) Leclanche cell.

Numerical Value Type

26. The rate of a first order reaction is 1.8×10^{-3} mol L^{-1} min^{-1} when the initial concentration is 0.3 mol L^{-1}. The rate constant is $x \times 10^{-4}$ s^{-1}. The value of x is _____.

27. When an electric current is passed through acidified water, 112 mL of hydrogen gas at N.T.P. was collected at the cathode in 965 seconds. The current passed, in ampere, is _____.

28. The rate of reaction decreased by 3.555 times when the temperature was changed from 40°C to 30°C. The activation energy (in kJ mol^{-1}) of the reaction is _____. Take; $R = 8.314\ J\ mol^{-1}\ K^{-1}$ and $\ln 3.555 = 1.268$ **(JEE Main 2020)**

29. The kinetic data for the given reaction, $A_{(g)} + 2B_{(g)} \xrightarrow{k} C_{(g)}$ is provided in the following table for three experiments at 300 K.

Ex. No.	[A/M]	[B/M]	Initial rate M(sec^{-1})
1.	0.01	0.01	6.930×10^{-6}
2.	0.02	0.01	1.386×10^{-5}
3.	0.02	0.02	1.386×10^{-5}

In another experiment starting with initial concentration of 0.5 M and 1 M respectively for A and B at 300 K. The rate of reaction after 50 minutes from start of experiment (in M/sec) is $x \times 10^{-5}$. The value of x is _____.

30. For the reactions, $A \longrightarrow B$; $k_1 = 10^8 e^{-\frac{6000}{8.34T}}$

and $P \longrightarrow Q$; $k_2 = 10^{10} e^{-\frac{8000}{8.34T}}$

The temperature (in K) at which $k_1 = k_2$ is _____.

SOLUTIONS

1. **(b):** $G^* = \kappa R = (6.67 \times 10^{-3}\ \Omega^{-1}\ cm^{-1})\ (243\ \Omega)$
$= 1.62\ cm^{-1}$.

2. **(b):** $Fe^{2+} + 2e^- \rightarrow Fe$; $E^\circ_{Fe^{2+}/Fe} = x_1$ V
$\Delta G_1 = -nFE_1 = -2x_1F$
$Fe^{3+} + e^- \rightarrow Fe^{2+}$; $E^\circ_{Fe^{3+}/Fe^{2+}} = x_2$ V
$\Delta G_2 = -nFE_2 = -1x_2F$
$Fe^{3+} + 3e^- \rightarrow Fe$; $E^\circ_{Fe^{3+}/Fe} = ?$
$\Delta G_3 = \Delta G_1 + \Delta G_2$
$-nFE_3 = -2x_1F - x_2F \Rightarrow -3E_3 = -2x_1 - x_2$
$E_3 = \left(\frac{2x_1 + x_2}{3}\right)$

3. **(d):** According to Nernst equation,
$E_{cell} = E^\circ_{cell} - \frac{0.059}{n} \log Q_c$
At equilibrium $E_{cell} = 0$, $\therefore$ $Q_c = K_c$
$E^\circ_{cell} = \frac{0.059}{n} \log K_c \Rightarrow 0.59 = \frac{0.059}{1} \log K_c$
$K_c = \text{antilog } 10 \Rightarrow K_c = 1 \times 10^{10}$

4. **(d):** A radioactive disintegration reaction is always of 1st order. $[A]_0 = 10[A]$; $t_{1/2} = 30$ days
$k = \frac{0.693}{t_{1/2}} = \frac{0.693}{30}$
$t = \frac{2.303}{k} \log \frac{[A]_0}{[A]} = \frac{2.303}{0.693} \times 30 \times \log \frac{10[A]}{[A]}$
$= 99.7 \approx 100$ days

5. **(b)**

6. **(b):** $H_2SO_4 \rightleftharpoons 2H^+ + SO_4^{2-}$
2×96500 C liberates 1 mole of H_2
$HCl \rightleftharpoons H^+ + Cl^-$
96500 C liberates $\frac{1}{2}$ mole of H_2 and therefore 2×96500 C liberates 1 mole of hydrogen.

7. **(c):** $r_1 = k[A]^1$, $r_2 = k[A]^2$, $r_3 = k[A]^3$
If $[A] > 1$M ; then $r_3 > r_2 > r_1$

8. **(b)**

9. **(d):** The substances whose aqueous solutions allow the passage of electric current and are chemically decomposed are termed as electrolytes. Electrolytic substances are classified as strong or weak according to how readily they dissociate into conducting ions. Acetic acid is a weak electrolyte. Glucose, ethanol and urea are non-electrolytes.

10. **(b)**

11. **(d):** For concentration cell, $E^\circ_{cell} = 0$
$E_{cell} = E^\circ_{cell} - \frac{0.059}{2} \log \frac{C_1}{C_2}$; $E_{cell} = -\frac{0.059}{2} \log \frac{C_1}{C_2}$
As $\Delta G = -nFE_{cell}$
For $\Delta G = -ve$, $E_{cell} > 0 \Rightarrow C_2 > C_1$

12. **(a):** More is E°_{RP}, more is oxidizing power or lesser is reducing power.

13. **(a):** $k_2 = \frac{2.303}{t_2} \log \frac{100}{50}$ for 50% of B reacted

$k_1 = \frac{2.303}{t_1} \log \frac{100}{6}$ for 94% of A reacted

$\therefore$ $\frac{k_2}{k_1} = \frac{t_1}{t_2} \times \frac{0.3010}{1.2218}$

Since $t_2 = t_1$, because 50% of B has reacted when 94% A has reacted.

$\therefore$ $\frac{k_2}{k_1} = \frac{0.3010}{1.2218} = 0.246$ and $\frac{k_1}{k_2} = 4.06$

14. **(c):** $k_1 = A_1 e^{-E_{a_1}/RT}$; $k_2 = A_2 e^{-E_{a_2}/RT}$

$\frac{k_1}{k_2} = \left(\frac{A_1}{A_2}\right) e^{\frac{-E_{a_1} + E_{a_2}}{RT}}$

Now, $\frac{A_1}{A_2}$ = constant and $E_{a_2} = 2E_{a_1}$

$\frac{k_1}{k_2} = A\, e^{\frac{-E_{a_1} + 2E_{a_1}}{RT}} \Rightarrow \frac{k_1}{k_2} = A\, e^{E_{a_1}/RT}$

or $k_1 = Ak_2 e^{E_{a_1}/RT}$

15. (a) : As at the completion of reaction 35 mL of O_2 is formed, hence 70 mL of N_2O_5 is present initially as from the reaction we can see that,

$$N_2O_5 : N_2O_4 : O_2 :: 1 : 1 : \frac{1}{2}$$

$$N_2O_5 \rightleftharpoons N_2O_4 + \frac{1}{2}O_2$$

Initial	70 mL	0	0
After 15 min.	70-18 mL	18 mL	9 mL

For first order reaction

$$k = \frac{1}{t}\ln\frac{a}{a-x} = \frac{1}{15}\ln\frac{70}{52} \text{ or } \frac{1}{15}\ln\frac{35}{26}$$

16. (c) : For a first order reaction,

$$k = \frac{2.303}{t}\log\frac{[R]_0}{[R]}$$

$$\Rightarrow t = \frac{2.303}{4.606\times10^{-3}\ s^{-1}}\log\left(\frac{2}{0.2}\right) = \frac{2.303\times10^3}{4.606} = 500\ s$$

17. (a) : From Kohlrausch's law,

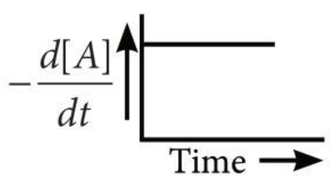
$$\Lambda^\circ_{CH_3COOH} = \Lambda^\circ_{CH_3COONa} + \Lambda^\circ_{HCl} - \Lambda^\circ_{NaCl}$$

18. (a)

19. (c) : From given graph $x = kt$

i.e., it is a zero order reaction.

$$\therefore \quad -\frac{d[A]}{dt} = k$$



20. (a) : $CuSO_4 + 2e^- \rightarrow Cu + SO_4^{2-}$

$Bi_2(SO_4)_3 + 6e^- \rightarrow 2Bi + 3SO_4^{2-}$

$AlCl_3 + 3e^- \rightarrow Al + 3Cl^-$

$AgNO_3 + e^- \rightarrow Ag + NO_3^-$

21. (a)

22. (b) : $\Lambda_{eq} = \frac{\kappa\times1000}{\text{Normality}}$

and $\kappa \propto \frac{l}{A}$ $\qquad \left[\frac{l}{A} = \text{cell constant}\right]$

23. (a) : From Arrhenius equation, $\ln k = \ln A - \frac{E_a}{RT}$

$$\text{Slope} = \frac{-E_a}{R} = -4606\ K \text{ or, } \ln\frac{k_2}{k_1} = \frac{E_a}{R}\left(\frac{T_2 - T_1}{T_1T_2}\right)$$

$$\ln\frac{k_2}{10^{-5}} = 4606\left(\frac{500-400}{500\times400}\right)$$

$$\ln\frac{k_2}{10^{-5}} = 2.303;\ \frac{k_2}{10^{-5}} = \text{antiln}\ (2.303)$$

$$k_2 = 1\times10^{-4}\ s^{-1}$$

24. (d): $\frac{r_{new}}{r} = \frac{k[2A]^n\left[\frac{1}{2}B\right]^m}{k[A]^n[B]^m} = 2^n\times\frac{1}{2^m} = 2^{(n-m)}$

25. (b) : $H_2 - O_2$ cell

26. (1) : Rate $= k[A]$

$$1.8\times10^{-3}\ \text{mol}\ L^{-1}\ \text{min}^{-1} = k\times0.3\ \text{mol}\ L^{-1}$$

$$\therefore \quad k = \frac{1.8\times10^{-3}}{0.3\times60} = 1\times10^{-4}\ s^{-1}$$

27. (1) : $2H^+ + 2e^- \rightarrow H_2$ (at cathode)

$$w = ZIt = \frac{EIt}{96500}$$

Moles of H_2 deposited $= \frac{112}{22400}$

Mass of H_2 deposited (w) = Moles × Molar mass

$$= \frac{112}{22400}\times2$$

Thus, $\frac{112}{22400}\times2 = \frac{1\times I\times965}{96500} \quad \Rightarrow \quad I = 1\ A$

28. (100) : Given, $\frac{k_{T_2}}{k_{T_1}} = 3.555$

$T_1 = 30 + 273 = 303$ K, $T_2 = 40 + 273 = 313$ K

$$\ln\left(\frac{k_{T_2}}{k_{T_1}}\right) = \frac{E_a}{R}\left(\frac{1}{303} - \frac{1}{313}\right)$$

$$\ln(3.555) = \frac{E_a}{8.314}\left(\frac{1}{303} - \frac{1}{313}\right)$$

$$E_a = \frac{1.268\times8.314\times303\times313}{10} = 99980.7\ J/\ mol$$

$$= 99.98\ kJ/mol \approx 100\ kJ/mol$$

29. (4.36) : $r_1 = k[0.01]^a\ [0.01]^b = 6.93\times10^{-6}$ ...(i)

$r_2 = k[0.02]^a\ [0.01]^b = 1.386\times10^{-5}$ ...(ii)

$r_3 = k[0.02]^a\ [0.02]^b = 1.386\times10^{-5}$ ...(iii)

From data $a = 1$; $b = 0$

Overall order = 1 ; $k = 6.93\times10^{-4}\ sec^{-1}$

$$6.93\times10^{-4} = \frac{1}{50\times60}\ln\frac{A_0}{A_t};\ 2.07 = \ln\frac{A_0}{A_t}$$

$$\Rightarrow \quad 7.92 = \frac{A_0}{A_t}\ ;\ A_t = \frac{0.5}{7.92}$$

$A_t = 0.0631$

Rate of reaction $= 6.93\times10^{-4}\times0.0631$

$= 4.36\times10^{-5}\ Ms^{-1}$

30. (52) : $k_1 = k_2$

$$10^8\ e^{-\frac{6000}{8.34T}} = 10^{10}\ e^{-\frac{8000}{8.34T}}$$

$$\frac{10^{10}}{10^8} = e^{\frac{2000}{8.34T}}$$

$$\Rightarrow \quad 2.303\log100 = \frac{2000}{8.34\ T} \Rightarrow T = \frac{2000}{2.303\times2\times8.34}$$

$= 52$ K

CBSE warm-up!

CLASS-XII

TERM-I OBJECTIVE TYPE QUESTIONS*

Unit 1 The Solid State | Solutions

MCQs

1. A solid has a structure in which, atoms of W, O and Na are located respectively at the corners, centre of edges and at the centre of the cubic lattice. The compound is

(a) $NaWO_2$ (b) $NaWO_3$
(c) Na_2WO_3 (d) $NaWO_4$

2. The vapour pressure of water at 20 °C is 17.5 mm Hg. If 18 g of glucose ($C_6H_{12}O_6$) is added to 178.2 g of water at 20 °C, the vapour pressure of the resulting solution will be

(a) 17.325 mm Hg (b) 17.675 mm Hg
(c) 15.750 mm Hg (d) 16.500 mm Hg

3. The substance magnetite is

(a) ferromagnetic (b) diamagnetic
(c) antiferromagnetic (d) ferrimagnetic.

4. Which one of the following is a covalent crystal?

(a) Rock salt (b) Ice
(c) Quartz (d) Dry ice

5. The pure crystalline substance when heated gradually first forms a turbid liquid at constant temperature and still at higher temperature, turbidity completely disappears. The behaviour is a characteristic of substance forming

(a) allotropic crystals
(b) liquid crystals
(c) isomeric crystals
(d) isomorphous crystals.

6. Equimolal solutions of KCl and compound *X* in water shows depressions in freezing point in the ratio of 4 : 1. Assuming KCl to be completely ionised, the compound *X* in solution must

(a) dissociate to the extent of 50%
(b) hydrolyse to the extent of 80%
(c) dimerise to the extent of 50%
(d) trimerise to the extent of 75%

7. The density of solid argon is 1.65 g per cc at –233°C. If the argon atom is assumed to be a sphere of radius 1.54×10^{-8} cm, what percent of solid argon is apparently empty space? (Ar = 40)

(a) 16.5% (b) 38%
(c) 50% (d) 62%

8. Conduction in a *p*-type semiconductor is increased by

(a) increasing the band gap
(b) decreasing the temperature
(c) adding appropriate electron deficient impurities
(d) adding appropriate electron rich impurities.

9. On mixing, heptane and octane form an ideal solution. At 373 K, the vapour pressure of the two liquid components (heptane and octane) are 105 kPa and 45 kPa respectively. Vapour pressure of the solution obtained by mixing 25 g of heptane and 35 g of octane will be (molar mass of heptane = 100 g mol^{-1} and of octane = 114 g mol^{-1})

(a) 144.5 kPa (b) 72.0 kPa
(c) 36.1 kPa (d) 96.2 kPa

Chapterwise practice questions for CBSE Exam Term- I as per the pattern issued by CBSE.

10. Potassium dichromate belongs to which crystal system?
(a) Tetragonal (b) Orthorhombic
(c) Triclinic (d) Hexagonal

11. The ionic radii of Rb^+ and I^- are 1.46 and 2.16 Å respectively. The most possible type of structure exhibited by it, is
(a) CsCl type (b) NaCl type
(c) ZnS type (d) CaF_2 type.

12. Schottky defect in crystals is observed when
(a) an ion leaves its normal site and occupies an interstitial site
(b) unequal number of cations and anions are missing from the crystal lattice
(c) equal number of cations and anions are missing from the crystal lattice
(d) there is large difference in size of positive and negative ions.

13. Which one of the following is correct about ferrites?
(a) These possess formula AB_2O_4 (where A is divalent and B is trivalent cation).
(b) These possess spinel structure.
(c) $MgAl_2O_4$ is a ferrite. (d) All of the above.

14. The vapour pressure of pure benzene and toluene are 160 and 60 torr respectively. The mole fraction of toluene in vapour phase in contact with equimolar solution of benzene and toluene is
(a) 0.50 (b) 0.16 (c) 0.27 (d) 0.73

15. The crystal structure of solid Mn(II) oxide is
(a) NaCl structure (b) Fe_2O_3 structure
(c) CaF_2 structure (d) Na_2O structure.

16. Two ions A^+ and B^- have radii of 0.88 Å and 2Å, respectively. What will be the type of crystal?
(a) *fcc* (b) *bcc*
(c) Simple cubic (d) none of these

17. A metal has *bcc* structure and the edge length of its unit cell is 3.04 Å. The volume of the unit cell in cm^3 will be
(a) 1.6×10^{21} (b) 2.81×10^{-23}
(c) 6.02×10^{-23} (d) 6.6×10^{-24}

18. On mixing 25 mL of acetone with 25 mL of ethyl alcohol, the total volume of solution is
(a) = 50 mL (b) > 50 mL
(c) < 50 mL (d) unpredictable.

19. CsCl has coordination number ratio
(a) 6 : 6 (b) 8 : 8
(c) 4 : 4 (d) none of these.

20. Molecules/ions and their magnetic properties are given below.

Molecule/ion	Magnetic property
(i) C_6H_6	(1) Antiferromagnetic
(ii) CrO_2	(2) Ferrimagnetic
(iii) MnO	(3) Ferromagnetic
(iv) Fe_3O_4	(4) Paramagnetic
(v) Fe^{3+}	(5) Diamagnetic

The correctly matched pairs in the above is
(a) i-5, ii-3, iii-2, iv-1, v-4
(b) i-3, ii-5, iii-1, iv-4, v-2
(c) i-5, ii-3, iii-1, iv-2, v-4
(d) i-5, ii-3, iii-1, iv-4, v-2

21. Azeotropic mixture of HCl and H_2O has
(a) 36% HCl (b) 48% HCl
(c) 20.2% HCl (d) 22.2% HCl

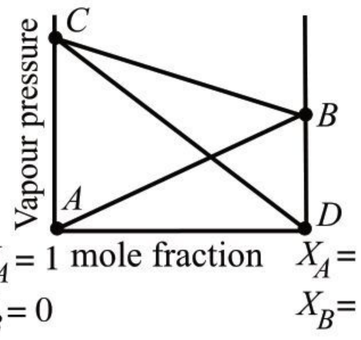
22. A compound of copper and gold crystallises in a cubic lattice in which the copper atoms occupy the centres of each of the cube faces and the gold atoms occupy the lattice point. The formula of compound is
(a) Au_3Cu (b) $AuCu_3$
(c) Au_2Cu_3 (d) Au_3Cu_2

23. When a cation leaves its normal position in the crystal and moves to some interstitial space, the defect in the crystal is known as
(a) Schottky defect (b) *F*-centre
(c) Frenkel defect
(d) non-stoichiometric defect.

24. Empty space in *ccp* lattice is
(a) 26% (b) 45% (c) 90% (d) 30%

25. The vacant space in *bcc* lattice unit cell is
(a) 48% (b) 23% (c) 32% (d) 26%

26. In the mixtures of two miscible volatile liquids obeying Raoults' law, the correct behaviour is explained by



(a) *AB* stands for the vapour pressure of component *B* in presence of solute *A*
(b) *CD* stands for the vapour pressure of solvent *A* in presence of solute *B*
(c) *BC* stands for the total vapour pressure in accordance with the Dalton's law of partial pressures
(d) all of the above.

27. The ratio of no. of atoms present in *fcc* and *bcc* unit cell is
(a) 1 : 2 (b) 4 : 2 (c) 1 : 3 (d) 2 : 4

28. Substance which is weakly repelled by a magnetic field is
(a) O_2 (b) H_2O (c) CrO_2 (d) Fe_3O_4

29. The vapour pressure lowering of a solvent is proportional to
(a) the mole fraction of the solute
(b) the mole fraction of the solvent
(c) the molality of the solvent
(d) the normality of the solution.

30. Sodium metal crystallizes in a body centred cubic lattice with a unit cell edge of 4.29 Å. The radius of sodium atom is approximately
(a) 5.72 Å (b) 0.93 Å (c) 1.86 Å (d) 3.22 Å

31. An element (atomic mass = 100 g/mol) having *bcc* structure has unit cell edge 400 pm. Then density of the element is
(a) 10.376 g/cm^3 (b) 5.188 g/cm^3
(c) 7.289 g/cm^3 (d) 2.144 g/cm^3

32. In the laboratory, sodium chloride is made by burning sodium in the atmosphere of chlorine. The salt obtained is yellow in colour. The cause of yellow colour is
(a) presence of Na^+ ions in the crystal lattice
(b) presence of Cl^- ions in the crystal lattice
(c) presence of electrons in the crystal lattice
(d) presence of face-centred cubic crystal lattice.

33. In a face centred cubic lattice, atom *A* occupies the corner positions and atom *B* occupies the face centre positions. If one atom of *B* is missing from one of the face centred points, the formula of the compound is
(a) A_2B (b) AB_2 (c) A_2B_3 (d) A_2B_5

34. Which of the following statements for crystals having Frenkel defect is not correct?
(a) Frenkel defects are observed where the difference in sizes of cations and anions is large.
(b) The density of crystals having Frenkel defect is lesser than that of a pure perfect crystal.
(c) An ionic crystal having Frenkel defect may also contain Schottky defect.
(d) none of these.

35. Coordination number of cations in rock Salt structure of NaCl is
(a) 4 (b) 6 (c) 8 (d) 9

36. The yellow colour of ZnO and conducting nature produced upon heating is due to
(a) metal excess defects due to interstitial cation
(b) extra positive ions present in an interstitial site
(c) trapped electrons
(d) all of these.

37. Suppose the mass of a single Ag atom is '*m*'. Ag metal crystallizes in *fcc* lattice with unit cell of length '*a*'. The density of Ag metal in terms of '*a*' and '*m*' is
(a) $\frac{4m}{a^3}$ (b) $\frac{2m}{a^3}$ (c) $\frac{m}{a^3}$ (d) $\frac{m}{4a^3}$

38. The crystal with metal deficiency defect is
(a) NaCl (b) FeO (c) KCl (d) ZnO

39. Schottky defect is
(a) vacancy of ions
(b) delocalization of ions
(c) interstitial vacancy of ions
(d) vacancy of only cations.

40. Potassium crystallises in a *bcc* structure. The coordination number of potassium is
(a) 4 (b) 8 (c) 6 (d) 10

41. The solubility of common salt is 36.0 g in 100 g of water at 20 °C. If systems, I, II and III contain 40.0, 36.0 and 20.0 g of the salt added to 100.0 g of water in each case, the vapour pressures would be in the order
(a) I < II < III (b) I > II > III
(c) I = II > III (d) I = II < III

42. CsBr crystallizes in a body-centred cubic unit lattice with an edge length of 4.287 Å. How many molecules of CsBr will be present in the unit lattice?
(a) 1 (b) 2 (c) 3 (d) 4

43. Which substance shows antiferromagnetism?
(a) TiO_2 (b) CuO (c) CrO_2 (d) Mn_2O_3

44. To get *n*-type doped semiconductor, impurity is to be added to silicon should have the following number of valence electrons
(a) 2 (b) 5 (c) 3 (d) 1

45. In zinc blende structure, the coordination number of the cation is
(a) 4 (b) 6 (c) 8 (d) 12

46. A supersaturated solution is a metastable state of solution in which solute concentration
(a) is equal to the solubility of that substance in water
(b) exceeds its solubility
(c) less than its solubility
(d) continuously changes.

47. Radius ratio of an ionic compound is 0.93. The structure of the above ionic compound is of
(a) NaCl type (b) CsCl type
(c) ZnS type (d) none of these.

48. A certain aqueous solution of $FeCl_3$ [formula mass = 162] has a density of 1.1 g/mL and contains 20.0% $FeCl_3$. Molar concentration of this solution is
(a) 0.028 (b) 0.163
(c) 1.357 (d) 1.47

49. If 18 g of glucose ($C_6H_{12}O_6$) is present in 1000 g of an aqueous solution of glucose, it is said to be
(a) 1 molal (b) 1.1 molal
(c) 0.5 molal (d) 0.1 molal

50. For co-ordination number 4, the limiting radius ratio is
(a) 0.414 (b) 0.732 (c) 0.225 (d) 0.155

CASE BASED

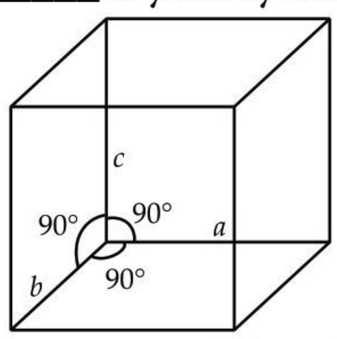
Read the passage given below and answer the following questions :

The adjective, 'crystalline' when applied to solids, implies an ideal crystal in which the structural units, termed as unit cells, are repeated regularly and indefinitely in three dimensions in space. The unit cell, containing at least one molecule, has a definite orientation and shape defined by the translational vectors, *a*, *b* and *c*. The unit cell therefore has a definite volume, *V* that contains the atoms and molecules necessary for generating the crystal. Every crystal can be classified as a member of one of the seven possible crystal systems or crystal classes that are defined by the relationships between the individual dimensions, *a*, *b* and *c* of the unit cell and between the individual angles, α, β and γ of the unit cell. The structure of the given crystal may be assigned to one of the 7 crystal systems, to one of the 14 Bravais lattices, and to one of the 230 space groups. These uniquely define the possible ways of arranging atoms in a three-dimensional solid. Based on these observations, seven crystal systems were identified : triclinic, monoclinic, trigonal or rhombohedral, tetragonal, hexagonal, rhombic or orthorhombic and cubic.

The following questions are multiple choice questions. Choose the most appropriate answer :

51. The crystal system of a compound with unit cell dimensions, $a = 0.387$ nm, $b = 0.387$ nm and $c = 0.504$ nm and $\alpha = \beta = 90°$ and $\gamma = 120°$ is
(a) cubic (b) hexagonal
(c) orthorhombic (d) rhombohedral.

52. The unit cell with the structure given below represents _____ crystal system.



(a) cubic (b) orthorhombic
(c) tetragonal (d) trigonal

53. In a triclinic crystal
(a) $a = b = c$, $\alpha = \beta = \gamma \neq 90°$
(b) $a \neq b = c$, $\alpha = \beta = \gamma = 90°$
(c) $a \neq b \neq c$, $\alpha \neq \beta \neq \gamma \neq 90°$
(d) $a \neq b \neq c$, $\alpha = \gamma = 90°$, $\beta \neq 90°$

54. The unit cell with dimensions $\alpha = \beta = \gamma = 90°$, $a = b \neq c$ is
(a) cubic (b) triclinic
(c) hexagonal (d) tetragonal.

55. An example of orthorhombic crystal system is
(a) SnO_2 (b) KNO_3
(c) ZnO (d) $K_2Cr_2O_7$

Read the passage given below and answer the following questions :

The concentration of a solute is very important in studying chemical reactions because it determines how often molecules collide in solution and thus indirectly determine the rate of reactions and the conditions at equilibrium.

There are several ways to express the amount of solute present in a solution. The concentration of a solution is a measure of the amount of solute that has been dissolved in a given amount of solvent or solution. Concentration can be expressed in terms of molarity, molality, parts per million, mass percentage, volume percentage, etc.

The following questions are multiple choice questions. Choose the most appropriate answer :

56. A solution is prepared using aqueous KI which is turned out to be 20% *w*/*w*. Density of KI is 1.202 g/mL. The molality of the given solution and mole fraction of solute are respectively
(a) 1.95 m, 0.120 (b) 1.5 m, 0.0263
(c) 2.5 m, 0.0569 (d) 3.0 m, 0.0352

57. The molarity (in mol L^{-1}) of the given solution will be
(a) 1.56 (b) 1.89
(c) 0.263 (d) 1.44

58. Which of the following is correct relationship between mole fraction and molality?

(a) $x_2 = \frac{mM_1}{1+mM_1}$ (b) $x_2 = \frac{mM_1}{1-mM_1}$

(c) $x_2 = \frac{1+mM_1}{mM_1}$ (d) $x_2 = \frac{1-mM_1}{mM_1}$

59. Which of the following is temperature dependent?
(a) Molarity (b) Molality
(c) Mole fraction (d) Mass percentage

60. Which of the following is true for an aqueous solution of the solute in terms of concentration?
(a) 1 M = 1 m (b) 1 M > 1 m
(c) 1 M < 1 m (d) Cannot be predicted

ASSERTION & REASON

In the following questions (Q. No. 61 - 70) a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.
(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.
(c) Assertion is correct statement but reason is wrong statement.
(d) Assertion is wrong statement but reason is correct statement.

61. **Assertion :** A solution is a homogeneous mixture of two or more chemically non-reacting substances.
Reason : Solutions can be made between any two states of matter.

62. **Assertion :** Glass is an amorphous solid.
Reason : Glass has an irregular, random arrangement of atoms.

63. **Assertion :** One molal aqueous solution of urea contains 60 g of urea in 1 kg of water.
Reason : Solution containing one mole of solute in 1000 g solvent is called one molal solution.

64. **Assertion :** One molar aqueous solution has always higher concentration than one molal.
Reason : The molality of a solution depends upon the density of the solution whereas molarity does not.

65. **Assertion :** The pressure exerted by a liquid at a given temperature is called its vapour pressure.
Reason : If a non-volatile solute is added to a solvent to give a solution, the vapour pressure of the solution is found to be greater than the vapour pressure of the pure solvent.

66. **Assertion :** At the same temperature, water has higher vapour pressure than acetic acid.
Reason : Hydrogen bonding in water is weaker than in acetic acid.

67. **Assertion :** Anionic vacancies in alkali halides are produced by heating the alkali halide crystals with alkali metal vapour.
Reason : Electrons trapped in anionic vacancies are referred to as *F*-centres.

68. **Assertion :** Solid NaCl does not conduct electricity at all.
Reason : There are Schottky defects in NaCl crystal.

69. **Assertion :** The packing efficiency is minimum for *fcc* structure.
Reason : The coordination number is 12 in *fcc* structure.

70. **Assertion :** On heating ferromagnetic or ferrimagnetic substances, they become paramagnetic.
Reason : The electrons randomly change their spin on heating.

SOLUTIONS

1. **(b) :** Number of atoms of W in a unit cell $= \frac{1}{8} \times 8 = 1$

Number of atoms of O in a unit cell $= \frac{1}{4} \times 12 = 3$

Number of atoms of Na in a unit cell = 1

$\therefore$ The compound is $NaWO_3$.

2. **(a) :** In solution containing non-volatile solute, pressure is directly proportional to its mole fraction.
Psolution = vapour pressure of its pure component × mole fraction in solution

$\therefore \quad P_{sol} = P^\circ X_{solvent}$

Let *A* be the solute and *B* the solvent

$$\therefore \quad X_B = \frac{n_B}{n_A + n_B} = \frac{\frac{178.2}{18}}{\frac{18}{180} + \frac{178.2}{18}} \Rightarrow X_B = \frac{9.9}{10} = 0.99$$

Now $P_{solution} = P^\circ X_{solvent} = 17.5 \times 0.99$

$P_{solution} = 17.32$ mm Hg

3. **(d)**

4. **(c) :** Quartz is a covalent crystal.

5. **(b) :** Liquid crystals on heating first become turbid and then clear.

6. (d) : $\frac{\Delta T_f(\text{KCl})}{\Delta T_f(X)} = \frac{4}{1} = \frac{i(\text{KCl})}{i(X)} = \frac{2}{i(X)} \Rightarrow i(X) = 0.5$

For association of 3 molecules,

$$i(X) = 1 - \left(1 - \frac{1}{n}\right)\alpha = 1 - \left(1 - \frac{1}{3}\right)\alpha = 0.5 \Rightarrow \alpha = 0.75$$

7. (d) : Volume of one molecule $= \frac{4}{3}\pi r^3$

$$= \frac{4}{3}\pi(1.54 \times 10^{-8})^3 \text{cm}^3 = 1.53 \times 10^{-23} \text{ cm}^3$$

Volume of all molecules in 1.65 g of Ar

$$= \frac{1.65}{40} \times N_A \times 1.53 \times 10^{-23} = 0.380 \text{ cm}^3$$

Volume of solid containing 1.65 g of Ar = 1 cm^3

$\therefore$ Empty space = 1 – 0.380 = 0.620

$\therefore$ Percent of empty space = 62%

8. (c) : Adding electron deficient impurities creates an abundance of holes. These holes are majority carriers in *p*-type semiconductors and are responsible for conduction.

9. (b) : Given, P°_{heptane} = 105 kPa

P°_{octane} = 45 kPa, w_{heptane} = 25 g, w_{octane} = 35 g

$$n_{\text{heptane}} = \frac{25}{100} = 0.25 \Rightarrow n_{\text{octane}} = \frac{35}{114} = 0.30$$

$$x_{\text{heptane}} = \frac{0.25}{0.25 + 0.30} = 0.45$$

$$\Rightarrow \quad x_{\text{octane}} = \frac{0.30}{0.25 + 0.30} = 0.54$$

$$P_{\text{Total}} = x_{\text{heptane}} P^\circ_{\text{heptane}} + x_{\text{octane}} P^\circ_{\text{octane}}$$

$$= 0.45 \times 105 + 0.54 \times 45$$

$$= 47.25 + 24.3 = 71.55 \approx 72 \text{ kPa}$$

10. (c)

11. (b) : r_{Rb^+} = 1.46 Å

r_{I^-} = 2.16 Å $\qquad \frac{r_+}{r_-} = 0.675$

As radius ratio lies in between 0.414 – 0.732, so, possible structure is NaCl type.

12. (c) : In order to maintain electrical neutrality, the number of missing cations and anions are equal in Schottky defect.

13. (d) : Ferrites are mixed oxides wherein the O^{2-} ions are cubic close-packed with the larger divalent ions in one quarter of the octahedral holes and half of the smaller trivalent ions occupy both octahedral and tetrahedral holes. Their general formula is AB_2O_4 *e.g.*, Fe_3O_4 is an inverse spinel having formula $Fe^{II}Fe_2{}^{III}O_4$. $MgAl_2O_4$ is a ferrite with a spinel structure where Mg^{2+} ions occupy tetrahedral holes and Al^{3+} ions occupy octahedral holes.

14. (c) : For equimolar solution, let us take

$x^A = x^B = 0.5$

$P_{\text{benzene}} = 160 \times 0.5 = 80$ torr,

$P_{\text{toluene}} = 60 \times 0.5 = 30$ torr

$P_{\text{total}} = 80 + 30 = 110$ torr

Mole fraction of toluene in vapour phase

$$= \frac{\text{Partial vapour pressure of toluene}}{\text{Total vapour pressure}} = \frac{30}{110} = 0.27$$

15. (a) : MnO has the NaCl, rock salt structure, where both cations and anions are octahedrally coordinated.

16. (a) : $\frac{r_{(A^+)}}{r_{(B^-)}} = \frac{0.88}{2} = 0.44$

Radius ratio falls in the range 0.414 – 0.732. Hence crystal is of *fcc* type.

17. (b) : Volume of unit cell (V) = a^3

= $(3.04 \times 10^{-8} \text{ cm})^3 = 2.81 \times 10^{-23} \text{ cm}^3$

18. (b) : The solution shows positive deviation where ΔV_{mix} = positive.

19. (b)

20. (c) : C_6H_6 is diamagnetic (i - 5)

CrO_2 is ferromagnetic (ii - 3)

MnO is antiferromagnetic (iii - 1)

Fe_3O_4 is ferrimagnetic (iv - 2)

Fe^{3+} is paramagnetic with 5 unpaired electrons (v - 4)

21. (c) : Azeotropic mixtures are those mixtures which boils at a constant temperature and distill over completely at the same temperature without change in composition.

In HCl + H_2O azeotropic mixture, HCl composition is 20.2% and water is 79.8%.

22. (b) : No. of atoms of gold (Au) in a unit cell

= 1/8 × 8 = 1

No. of atoms of copper (Cu) in a unit cell = 1/2 × 6 = 3

Hence, formula of the compound is $AuCu_3$.

23. (c)

24. (a) : In *ccp* lattice, 74% of the space is occupied by spheres and 26% is empty.

25. (c) : Packing efficiency of *bcc* lattice = 68%

Hence, empty space = 32%.

26. (d)

27. (b) : No. of atoms per unit cell in *fcc* = 4
No. of atoms per unit cell in *bcc* = 2
Ratio (*fcc* : *bcc*) = 4 : 2

28. (b) : Substances which are weakly repelled by external magnetic field are called diamagnetic substances, *e.g.* H_2O.

29. (a) : $\frac{p^\circ - p_s}{p^\circ} = X_2$ (Raoult's law)

30. (c) : For *bcc*, $r = \frac{\sqrt{3}}{4}a$, $r = \frac{\sqrt{3}}{4} \times 4.29 = 1.86$ Å

31. (b) : $\text{Density} = \frac{Z \times M}{a^3 \times N_A \times 10^{-30}}$

$$= \frac{2 \times 100}{(400)^3 \times 6.023 \times 10^{23} \times 10^{-30}} = 5.188 \text{ g/cc}$$

32. (c) : Yellow colour on heating NaCl in presence of Na is due to presence of electrons in anion vacancies (F-centre).

33. (d) :

A	*B*
$8 \times \frac{1}{8}$	$5 \times \frac{1}{2}$

Formula of the compound is A_2B_5.

34. (b) : In Frenkel defect, the ion, instead of being in its expected location, is found in one of the interstitial sites.
The density of crystals exhibiting Frenkel defects remains unchanged as the ions are present in the interstitial sites without changing the volume of the substance.

35. (b) : Coordination number of both cations and anions is 6 : 6 in rock salt structure.

36. (d)

37. (a) : $\text{Density} = \frac{\text{Mass of the unit cell}}{\text{Volume of the unit cell}}$

$$= \frac{\text{No. of atoms} \times \text{Mass of each atom}}{\text{Volume of the unit cell}} = \frac{4 \times m}{a^3}$$

($\because$ in *fcc*, no. of atoms = 4)

38. (b) : There are many solids which are difficult to prepare in the stoichiometric proportion. A typical example of this type is FeO which is mostly found with a composition of $Fe_{0.95}O$. It may actually range from $Fe_{0.93}O$ to $Fe_{0.96}O$. In crystals of FeO some Fe^{2+} cations are missing and the loss of positive charge is made up by the presence of required number of Fe^{3+} ions.

39. (a) : In Schottky defect, some of the lattice points are unoccupied (vacancies or holes). The number of missing cations and anions is the same, thus crystal remains neutral.

40. (b)

41. (d) : I is super saturated, II is saturated and III is unsaturated solution. In solution I and II, amount of dissolved substance is same.

42. (a) : Edge length of cube, $a = 4.287 \times 10^{-8}$ cm
Volume of unit cell, $a^3 = 7.8788 \times 10^{-23}$ cm^3
Mass of unit cell = Volume × Density
$213 = 7.8788 \times 10^{-23} \times \text{Density}$
Density, $\rho = 2.70345 \times 10^{24}$

$$\text{No. of molecules} = \frac{a^3\rho}{M} = 0.99 \approx 1.00$$

43. (d) : Mn_2O_3 shows antiferromagnetism.

44. (b) : To get *n*-type semiconductor, doping should be done with next group element. Thus, for making silicon (14^{th} group) a *n*-type semiconductor, it should be doped with an element of 15^{th} group with 5 valence electrons.

45. (a) : It has cubic closed packed structure. S^{2-} ions are present at the corners of the cube and at the centre of each face. Zn^{2+} ions occupy half of the tetrahedral sites. Each Zn^{2+} is surrounded by four S^{2-} ions and each S^{2-} ion is surrounded by four Zn^{2+} ions.

46. (b) : When a saturated solution prepared at a higher temperature is cooled, it gives a solution which contains usually more of solute than required for the saturated solution at that temperature. Such a solution is referred to as a supersaturated solution. It is usually unstable and changes to saturated solution when excess of solute comes out in solid state.

47. (b) : Radius ratio range 0.732 – 1.000 signifies co-ordination number 8. In CsCl, co-ordination number ratio is 8 : 8.

48. (c) : 20% $FeCl_3$ solution means 100 g of solution contains 20 g $FeCl_3$.

$\Rightarrow$ Volume of 100 g solution $= \frac{100 \text{ g}}{1.1 \text{ g/mL}} = 90.91$ mL

Moles of 20 g $FeCl_3 = \frac{20}{162} = 0.1234$ mole

$\Rightarrow$ Molar concentration of solution

$$= \frac{0.1234}{90.91} \times 1000 = 1.357 \text{ M}$$

49. (d) : 18 g glucose = $\frac{18}{180}$ mol = 0.1 mol

As it is present in 1000 g water, the solution is 0.1 molal.

50. (a) : For co-ordination number 4, the radius ratio range is 0.225 – 0.414.

51. (b) : For hexagonal crystal system, $a = b \neq c$ and $\alpha = \beta = 90°, \gamma = 120°$

52. (a) : Here, $a = b = c$; $\alpha = \beta = \gamma = 90°$
It belongs to cubic system.

53. (c)

54. (d) : For tetragonal crystal system, $a = b \neq c$ and $\alpha = \beta = \gamma = 90°$

55. (b) : KNO_3 has orthorhombic crystal structure.

56. (b) : Molar mass of KI = 166 g/mol

$$n_{KI} = \frac{20}{166} = 0.12 \text{ mol}$$

$$\text{Molality} = \frac{n_{KI}}{w_{H_2O}} \times 1000 = \frac{0.12}{80} \times 1000 = 1.5 \text{ m}$$

$$n_{KI} = 0.12 \text{ and } n_{water} = \frac{80}{18} = 4.44$$

$$x_{KI} = \frac{n_{KI}}{n_{KI} + n_{H_2O}} = \frac{0.12}{0.12 + 4.44} = 0.0263$$

57. (d) : Density of solution = 1.202 g/mL

$$\text{Volume of solution} = \frac{100 \text{ g}}{1.202 \text{ g/mL}} = 83.2 \text{ mL}$$

$$\text{Molarity} = \frac{n_{KI}}{\text{Volume of solution in L}}$$

$$= \frac{0.120 \text{ mol}}{0.0832 \text{ L}} = 1.4423 \text{ mol L}^{-1}$$

58. (a) : $x_2 = \frac{n_2}{n_1 + n_2}$; $x_1 = \frac{n_1}{n_1 + n_2}$; $\frac{x_2}{x_1} = \frac{n_2}{n_1}$

$$\frac{x_2}{x_1} = \frac{m_2 / M_2}{m_1 / M_1} = \frac{m_2}{m_1} \times \frac{M_1}{M_2} \quad \text{...(i)}$$

$$\text{Molality} = \frac{n_2}{m_1} = \frac{m_2}{M_2 \times m_1} \quad \text{...(ii)}$$

From(i) and (ii), $m = \frac{x_2}{x_1} \times \frac{1}{M_1}$; $x_1 = 1 - x_2$

Hence, $x_2 = \frac{mM_1}{1 + mM_1}$

59. (a) : Mass does not depend on temperature while volume does. Hence, molarity depends on temperature.

60. (b) : 1 M solution contains 1 mole of solute in less than 1000 g of the solvent whereas 1 m solution has 1 mole of the solute in 1000 g of the solvent.

61. (b) : A homogeneous mixture consists of a single phase which has properties that may differ from those of the individual components *i.e.*, solute and solvent.

62. (a)

63. (a) : Molecular weight of urea (NH_2CONH_2)
= 14 + 2 + 12 + 16 + 14 + 2 = 60

$$\text{Number of moles} = \frac{\text{Weight}}{\text{Molecular weight}} = \frac{60}{60} = 1$$

$$m = \frac{\text{No. of moles of solute}}{\text{Mass of solvent in kg}} = \frac{1 \text{ mol}}{1 \text{ kg}} = 1 \text{m}$$

64. (b) : One molar aqueous solution has 1 mole in less than 1000 g of water. (At 4°C, density of water = 1 g/cc). Hence 1000 g of water will be associated with more than 1 mole while 1 molal has 1 mole in 1000 g of water.

65. (c) : The vapour pressure of solution is found to be lower than the vapour pressure of pure solvent. In the solution, the surface has both solute and solvent molecules, thereby the number of solvent molecules gets reduced at the surface, consequently, the number of solvent molecules escaping from the surface is correspondingly reduced and this results in the decrease of vapour pressure of the solvent.

66. (c) **67. (b)**

68. (d) : Solid NaCl conducts electricity to a very small extent. NaCl shows Schottky defect.

69. (d) : *fcc* is a close packed structure thus, it has maximum packing efficiency. The coordination number is 12 in *fcc* structure.

70. (a) : All magnetically ordered solids (ferromagnetic, ferrimagnetic and anti-ferromagnetic solids) transform to the paramagnetic state at high temperature due to the randomisation of spins.

MONTHLY TEST DRIVE

This specially designed column enables students to self analyse their extent of understanding of specified chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

Total Marks : 120

Aldehydes, Ketones and Carboxylic Acids

Time Taken : 60 Min.

NEET

Only One Option Correct Type

1. Which of the following reactions is a condensation reaction?

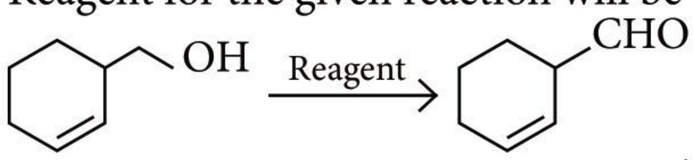
(a) $HCHO \longrightarrow$ Paraformaldehyde

(b) $CH_3CHO \longrightarrow$ Paraldehyde

(c) $CH_3COCH_3 \longrightarrow$ Mesityl oxide

(d) $CH_2=CH_2 \longrightarrow$ Polyethylene

2. Reagent for the given reaction will be



(a) hot acidic $KMnO_4$ (b) CrO_3, H^+

(c) CrO_3, pyridine, CH_2Cl_2

(d) dil. alkaline $KMnO_4$.

3. Which reagent is not suitable for the following conversion?

$Ph-CH=O \xrightarrow{\text{Reagent}} Ph-COOH$

(a) Tollens' reagent (b) Fehling solution

(c) $K_2Cr_2O_7$, H^+ (d) Acidic $KMnO_4$

4. Which of the following compounds can exhibit tautomerism?

(a) C_6H_5CHO (b) $C_6H_5COC(CH_3)_3$

(c) $C_6H_5COCH_2CHO$ (d) $C_6H_5COC_6H_5$

5. $CH_3CHO + 3HCHO \xrightarrow[I]{OH^-} (CH_2OH)_3CCHO$

$\xrightarrow[II]{OH^-} (CH_2OH)_4C + (CH_2OH)_3CCOO^-$

Reactions at stages I and II are respectively

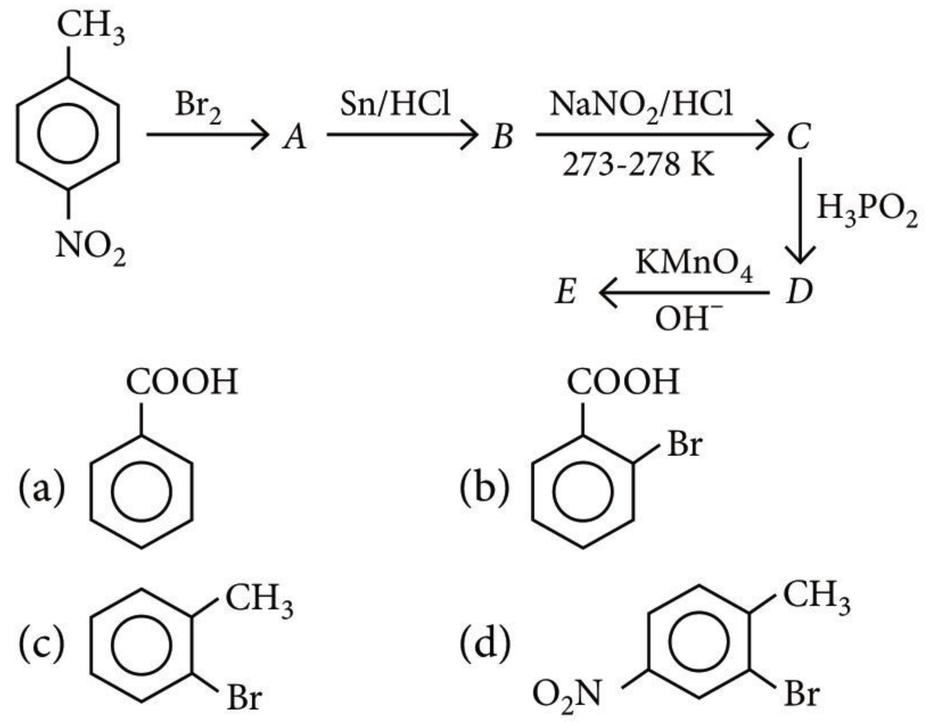
(a) Cannizzaro, aldol

(b) aldol, aldol

(c) Cannizzaro, Cannizzaro

(d) aldol, Cannizzaro.

6. Identify the product (E) in the following sequence of reactions.



(a) (b)

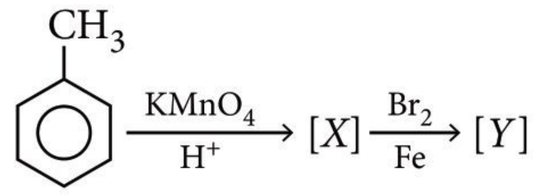
(c) (d)

7. Product obtained on the addition of an aqueous alkali to benzaldehyde followed by acid hydrolysis is

(a) benzoic acid (b) benzyl alcohol

(c) benzyl benzoate (d) all of these.

8. The final major product of the given reaction is



(a) (b)

(c) (d)

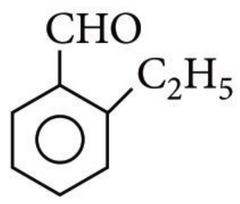
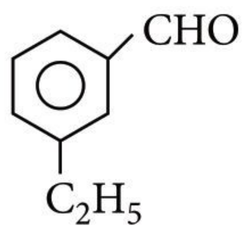
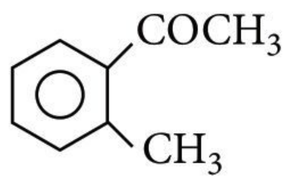
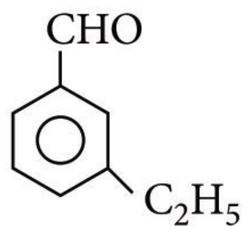
9. Which of the following is not a step of Cannizzaro reaction mechanism?

$2PhCHO \xrightarrow{O\bar{H}} PhCH_2OH + PhCOO^-$

(a) The attack of $O\bar{H}$ at the (C = O) group.
(b) The transfer of H^- ion to the (C = O) group.
(c) The abstraction of H^+ ion from carboxylic acid.
(d) The deprotonation of $PhCH_2OH$.

10. An aromatic compound '*X*' with molecular formula $C_9H_{10}O$ gives the following chemical tests :
(i) forms 2, 4-DNP derivative
(ii) reduces Tollens' reagent
(iii) undergoes Cannizzaro reaction, and
(iv) on vigorous oxidation, 1, 2-benzenedicarboxylic acid is obtained.

Identity the compound *X*.

(a) 
(b) 
(c) 
(d) 

11. Which of the following reactions can produce $R - CO - Ar$?
(a) $ArCOCl + H - Ar \xrightarrow{AlCl_3}$
(b) $RCOCl + ArMgX \longrightarrow$
(c) $ArCOCl + RMgX \longrightarrow$
(d) $RCOCl + H - Ar \xrightarrow{AlCl_3}$

12. When CH_3CHO reacts with excess of HCHO in the presence of a base, which statement is true?
(a) Only aldol-type (Claisen-Schmidt) reaction takes place.
(b) Only Cannizzaro-type (crossed Cannizzaro) reaction takes place.
(c) Both aldol-type and Cannizzaro-type reactions take place.
(d) None of these.

Assertion & Reason Type

Directions : In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as :
(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

13. **Assertion :** More electropositive element has greater electron donating effect.
Reason : Me_3SiCH_2COOH is more acidic than Me_3CCH_2COOH.

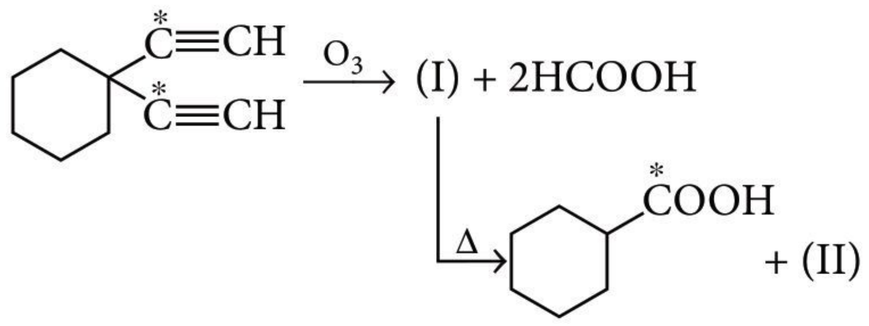
14. **Assertion :** α-Hydrogen atoms in aldehydes and ketones are acidic.
Reason : The anion left after the removal of α-hydrogen is stabilized by inductive effect.

15. **Assertion :** Esters which contain α-hydrogens undergo Claisen condensation.
Reason : $LiAlH_4$ reduction of esters gives acids.

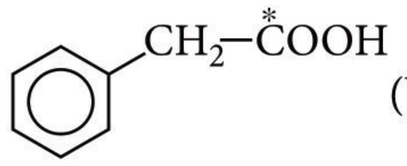
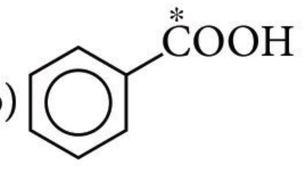
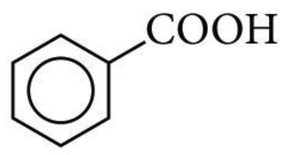
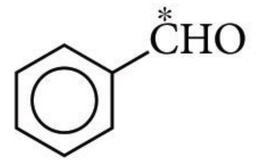
JEE MAIN / JEE ADVANCED

Only One Option Correct Type

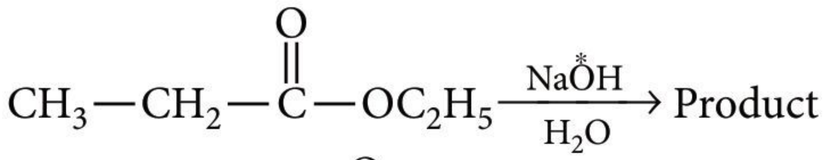
16. The product (III) of the following reactions sequence is

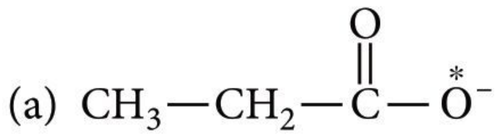
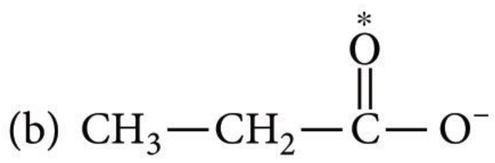
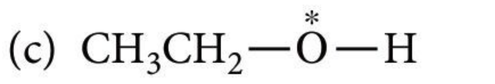
(i) 

(ii) $(II) \xrightarrow[(ii)\ H_3O^+]{(i)\ PhMgBr} (III)$

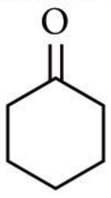
(a) 
(b) 
(c) 
(d) 

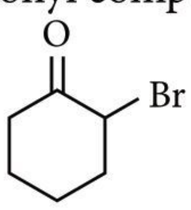
17. Identify the product for the given reaction.

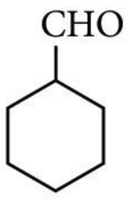


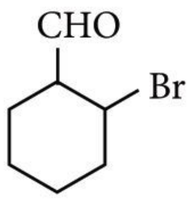
(a) 
(b) 
(c) 
(d) Both (a) and (b)

18. Consider the following carbonyl compounds :

I. 

II. 

III. 

IV. 

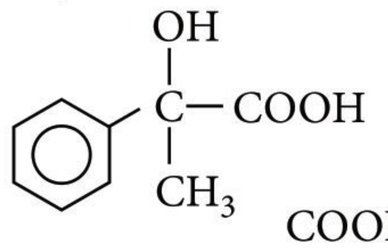
Which of the following is correct decreasing order of the extent of hydration or towards nucleophilic addition reactions?

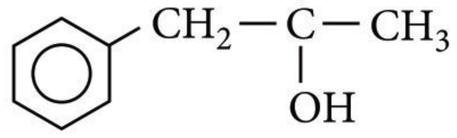
(a) (IV) > (III) > (II) > (I)
(b) (I) > (II) > (III) > (IV)
(c) (IV) > (II) > (III) > (I)
(d) (I) > (III) > (II) > (IV)

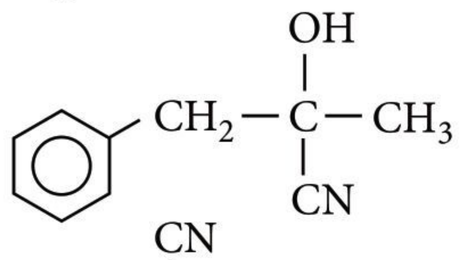
19. In a set of reactions, acid yielded a product *D*,

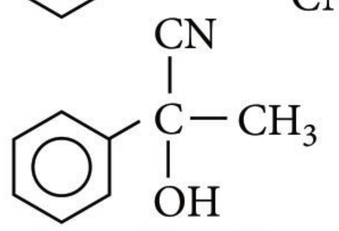
$$CH_3COOH \xrightarrow{SOCl_2} A \xrightarrow[\text{Anhy. } AlCl_3]{\text{Benzene}} B \xrightarrow{HCN} C \xrightarrow{HOH} D$$

identify *D*.

(a) 

(b) 

(c) 

(d) 

More than One Options Correct Type

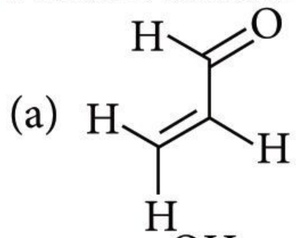
20. The correct statement(s) about the following reaction sequence is(are)

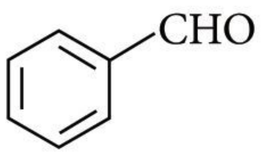
$$\text{Cumene}(C_9H_{12}) \xrightarrow[(ii)\ H_3O^+]{(i)\ O_2} P \xrightarrow[NaOH]{CHCl_3/} \underset{\text{(Major)}}{Q} + \underset{\text{(Minor)}}{R}$$

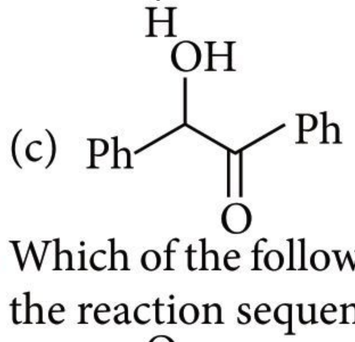
$$Q \xrightarrow[PhCH_2Br]{NaOH} S$$

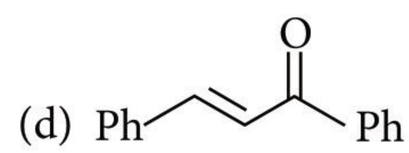
(a) *R* is steam volatile
(b) *Q* gives dark violet colouration with 1% aqueous $FeCl_3$ solution
(c) *S* gives yellow precipitate with 2, 4-dinitrophenylhydrazine
(d) *S* gives dark violet colouration with 1% aqueous $FeCl_3$ solution.

21. Positive Tollens' test is observed for

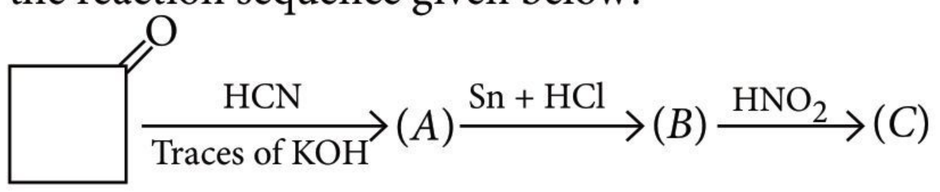
(a) 

(b) 

(c) 

(d) 

22. Which of the following statements are correct about the reaction sequence given below?



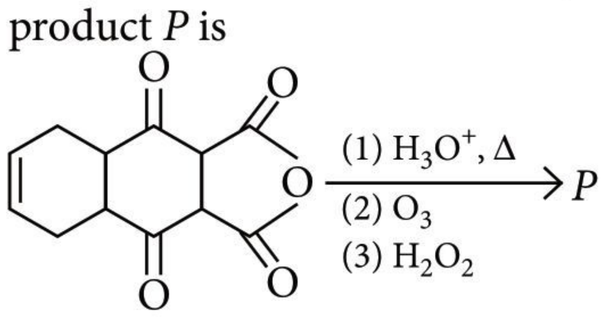
(a) In the formation of (*C*) from (*B*), ring expansion takes place.
(b) The product (*C*) is cyclopentanone.
(c) The product (*C*) is α, β-unsaturated cyclopentanone.
(d) Conversion of (*A*) to (*B*) can also be carried out with $LiAlH_4$.

23. Consider the following statements :

(a) On reaction with Grignard reagent follwed by hydrloysis acetone gives tertiary alcohol
(b) Mesitylene is a polymer of acetone
(c) Chloroform gives chloretone with acetone
(d) Acetone ammonia on losing water forms ethanalimine

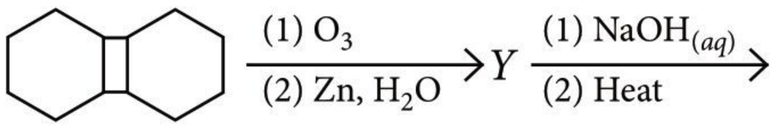
Integer / Numerical Value Type

24. The total number of carboxylic acid groups in product *P* is



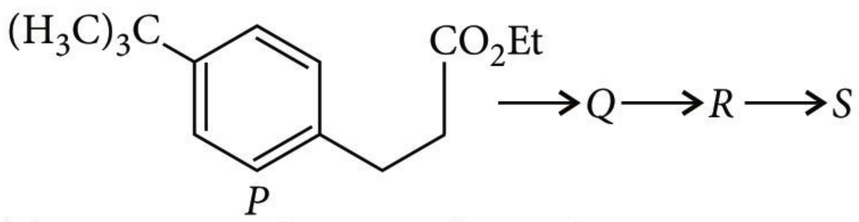
25. How many membered ring will be formed in product *P* of the following reaction.

26. In the scheme given below, the total number of intramolecular aldol condensation products formed from '*Y*' is



Comprehension Type

The reaction of compound *P* with CH_3MgBr (excess) in $(C_2H_5)_2O$ followed by addition of H_2O gives *Q*. The compound *Q* on treatment with H_2SO_4 at 0 °C gives *R*. The reaction of *R* with CH_3COCl in the presence of anhydrous $AlCl_3$ in CH_2Cl_2 followed by treatment with H_2O produces compound *S*. [Et in compound *P* is ethyl group]



27. The reactions, *Q* to *R* and *R* to *S*, are

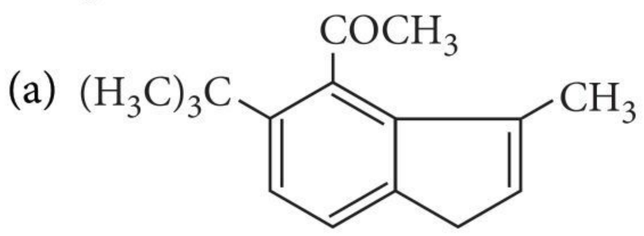
(a) Friedel–Crafts alkylation and Friedel–Crafts acylation

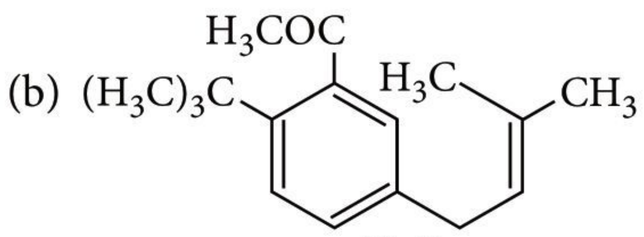
(b) dehydration and Friedel–Crafts acylation

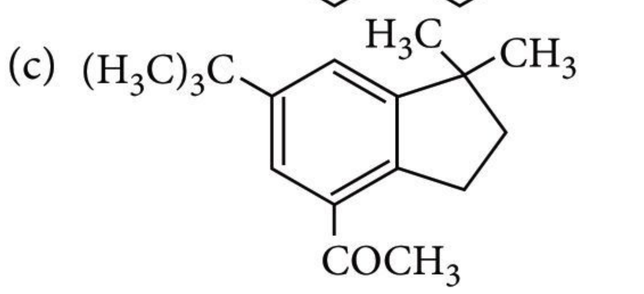
(c) Friedel–Crafts alkylation, dehydration and Friedel–Crafts acylation

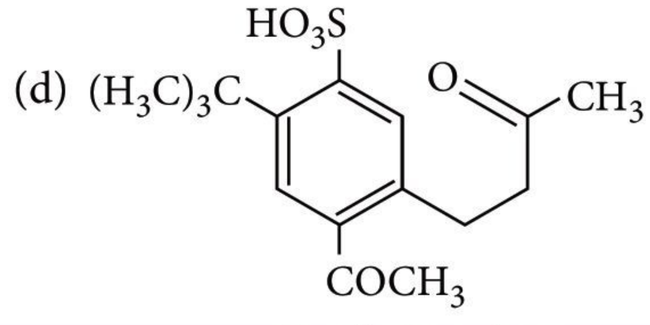
(d) aromatic sulphonation and Friedel–Crafts acylation.

28. The products *S* is

(a) 

(b) 

(c) 

(d) 

Matrix Match Type

29. Match the List I with List II and select the correct answer using the code given below the lists :

	List I	List II
P.	$CH_3CHO \rightarrow$ Aldol	1. $LiAlH_4$
Q.	$CH_3COOH \rightarrow CH_3CH_2OH$	2. Zn - Hg; Conc. HCl
R.	$CH_3COCH_3 \rightarrow CH_3CH_2CH_3$	3. Con. H_2SO_4
S.	$CH_3CHO \rightarrow (CH_3CHO)_3$	4. NaOH
		5. $KMnO_4$, H^+

	P	Q	R	S
(a)	5	2	1	3
(b)	4	1	2	3
(c)	2	5	1	4
(d)	4	2	5	4

30. Match the List I with List II and select the correct answer using the code given below the lists :

	List I	List II
P.	$CH_3COCH_3 \xrightarrow[\text{conc HCl}]{\text{Zn—Hg}}$	1. Phorone
Q.	$CH_3CHO \xrightarrow{H_2, Ni}$	2. CH_3CHO
R.	$CH_3—CH=CH_2 + PdCl_2 + H_2O \xrightarrow[H^+]{CuCl_2}$	3. CH_3COCH_3
S.	$CH_3COCH_3 \xrightarrow[H_2SO_4]{\text{Conc}}$	4. $CH_3CH_2CH_3$
		5. CH_3CH_3
		6. CH_3CH_2OH
		7. $C_6H_3(CH_3)_3$

	P	Q	R	S
(a)	5	2	3	1
(b)	4	6	3	7
(c)	5	6	4	3
(d)	5	6	4	2

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